*ECE 1000 Final Report: Micro Controlled Turbidity/TDS Sensor*

Zachary StClair

Tennessee Technological University

Department of Electrical and Computer Engineering

Cookeville, TN, USA

[zkstclair42@tntech.edu](mailto:zkstclair42@tntech.edu)

**Abstract** – The microcontroller-based Turbidity/Total Dissolved Solids (TDS) sensor necessitates an multidisciplinary approach, integrating principles from electrical engineering, civil engineering, and computer science, along with expertise in digital electronics and microcontroller programming. The device is engineered to measure essential water quality parameters using a Raspberry Pi Pico microcontroller. These measurements are subsequently interpreted through tailored water quality algorithms and displayed on an OLED screen in a manner that is both straightforward and comprehensible. Turbidity and TDS are pivotal metrics in the assessment of water quality. This paper elucidates the operational principles and design of the microcontroller-based Turbidity and TDS sensor, its prospective applications, and the benefits it may confer upon users.

1. INTRODUCTION

Every single life form on Earth requires water to survive. As humans, we typically do not recognize the steps taken by city utility companies to ensure our water is safe for consumption and use. Two of the most important metrics used for water safety testing are Turbidity and Total Dissolved Solids (TDS).

**Turbidity:** This refers to the measure of how much light scatters in water, providing insight into the cloudiness or murkiness of the water. A high turbidity reading (indicating low clarity) can suggest potential contamination with harmful materials.

**TDS (Total Dissolved Solids):** This metric indicates the total amount of organic and inorganic materials dissolved in water. Measured in parts per million (ppm), it offers an overall assessment of the water's chemical composition and the presence of dissolved substances. Drinking water typically should have a TDS level between 300 and 500 ppm. Higher TDS levels can indicate that the water might be less safe to drink.

1. PROGRAM DESCRIPTION AND FORMULATION

**MATERIALS:**

1. **Raspberry Pi Pico Micro Controller:** Serves as the main CPU, responsible for the decision making, reading information and sending information to the sensors and the OLED
2. **DF Robot Turbidity Sensor:** Emits light at a specific wavelength that detected the amount of light scattered by particles in the water.
3. **CQ Robot TDS Sensor: Measures the total concentration of ions in the water by assessing the electrical conductivity of the water the sensor is placed in.**
4. **UCTRONICS 0.96 OLED Display:** Displays the information received by the sensors

**FULL SYSTEM:**

Provided below is the full system with all components attached and wiring. The DF Robot turbidity sensor includes a potentiometer for calibration. Unfortunately, upon arrival, the potentiometer was found to be non-functional and could not be repaired, resulting in slightly inaccurate turbidity readings due to calibration issues. In contrast, the TDS sensor operated as expected.

A circuit board with wires and wires

Description automatically generated

**Functionality:**

The turbidity and Total Dissolved Solids (TDS) sensors are strategically placed within the sample of water that is to be tested. The system utilizes a microcontroller, programmed with MicroPython, which serves as the central processing unit for this setup. This firmware enables the microcontroller to collect the data

**Power the Sensors**: Upon execution of the code, the microcontroller activates both sensors by providing 3.3 Volts

**Turbidity Sensor**: The DF Robot turbidity sensor, despite its calibration limitations, measures the cloudiness of the water. It does this by emitting light into the water and detecting how much of this light is scattered at a 90-degree angle by particles in the water. The scattered light is converted into a voltage signal.

**TDS Sensor**: This sensor measures the electrical conductivity of the water, which correlates with the concentration of dissolved ionic substances. Higher ionic content increases conductivity, thus altering the voltage output.

**Transmit Raw Data**: The raw voltage readings from both sensors are transmitted back to a connected computer or processing unit via I2C.

**Data Processing on the Computer**:

**Calibration and Conversion**: The computer employs specific equations and algorithms to convert the raw analog voltage into meaningful units:

**Turbidity** is often expressed as percentage clarity, where lower clarity indicates higher turbidity.

**TDS** readings are converted into ppm (parts per million) or mg/L.

**Display on OLED**: After processing, the results are sent back to the microcontroller, which then displays the calculated turbidity (in clarity percentage) and TDS (in ppm) on an OLED screen. This visual feedback allows users to immediately assess the water quality without needing to interface directly with a computer.

1. **RESULTS**

To evaluate the effectiveness of the device, two distinct water samples were utilized for testing. The first sample consisted of Member's Mark Purified Water, while the second was river water collected locally, deliberately contaminated with mud and debris to simulate a high-turbidity environment.

**TDS Measurements**:

The TDS sensor measured 315 ppm for the purified water, which falls within the FDA's recommended range for drinking water (300-500 ppm), indicating its suitability for consumption.

For the river water, the TDS reading was 938 ppm, significantly exceeding the FDA's safety guidelines, suggesting that this water is not safe to drink.

**Turbidity Measurements**:

The turbidity sensor indicated 100% clarity for the purified water, reflecting its high purity.

The river water, however, only showed a 96% clarity reading, which, while lower, did not accurately reflect the expected decrease in clarity due to the added contaminants. This inaccuracy was attributed to the non-functional potentiometer on the turbidity sensor, which compromised calibration and hence the precision of the measurements.

A close-up of a glass container with wires

Description automatically generatedTwo plastic bottles with wires on a table

Description automatically generated

1. **CONCLUSION**

In conclusion, the project successfully demonstrated the capabilities of an micro controlled water quality monitoring system using both turbidity and TDS sensors. The TDS sensor provided reliable readings within the acceptable limits for drinking water as set by the FDA for the purified sample, confirming its practical utility in assessing water purity for consumption. However, the turbidity sensor's performance was hindered due to a calibration issue, which resulted in readings that did not fully capture the expected differences in water clarity. This limitation underscores the importance of component reliability in scientific instruments, particularly when sensor calibration is crucial for accurate environmental monitoring.

Despite the calibration challenge with the turbidity sensor, the overall system design showcased potential for real-time, on-site water quality analysis. Future changes could involve replacing the defective potentiometer to improve accuracy. Moreover, this project served as a practical application of sensor technology in Civil and Electrical Engineering. It has laid foundational insights for further development in water monitoring devices, potentially contributing to broader applications in public health and environmental protection.

1. R**EFERENCES**

[1] "Mellow\_labs," How to Use a Turbidity Sensor, Hackster.io, [2 Dec 2024]. [Online]. Available: [https://www.hackster.io/Mellow\_labs/how-to-use-a-turbidity-sensor-e9b3e7].

[2] "vezorgoat," -Raspberry-Pi-TDS-Sensor, GitHub, [2]. [Online]. Available: [https://github.com/vezorgoat/-Raspberry-Pi-TDS-Sensor].

[3] "AIChE," Bottled Water (Food and Drug Administration [FDA]), AIChE Institute for Sustainability, [1 Dec 2024]. [Online]. Available: [https://www.aiche.org/ifs/resources/glossary/isws-water-glossary/bottled-water-food-and-drug-administration-fda#:~:text=Mineral%20water%20containing%20less%20than,labeled%20“high%20mineral%20content”.].

[4] OpenAI, "ChatGPT," OpenAI, Dec. 2024. [Online]. Available: https://chat.openai.com/. [Accessed: Dec. 4, 2024].