Sensor-Based Water Quality Management

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Sensor-Based Water Quality Management

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ABSTRACT

Water is one of the vital elements for human being and all other organisms. The mixture of various type of dissolvable and non-dissolvable elements cause for changing the quality of water. The temperature of the water source is also considered as an important effective parameter. To help researchers about sensing the water quality and maintain the acceptances of its various parameters we are stands for the agreement of this project.

On the availability of some wonderful water sensor device, whose can be interfaced with microcontrollers such as Arduino ATMEGA32, we decided to develop this interface which combines the features of all available sensor-based reading about water acceptances parameters such as the potential of Hydrogen, dissolved Oxygen, turbidity, temperature, etc.

This document will discuss each of the underlying technologies to create and implement a microcontroller-based sensor-oriented water quality management.

DECLARATION

We declare that this project presented in it is our own and has been generated by us as the result of our own original work.

We confirm that:

- This Work is done wholly or mainly while in candidature for a degree at this University;
- This project has not been previously submitted for any degree at this university or any other educational institutes;
- We have quoted from the work of others; the source is always given. With the exception of such quotations, this project is entirely our own work;

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Chapter 1

Introduction

1.1 Introduction

To maintain the abstraction of nature, water is one of the vital elements for human being and all other organisms. The quality of water is responsible for qualify the water for usage in various purpose. The mixture of various type of dissolvable and non-dissolvable elements cause for changing the quality of water. The temperature of the water source is also considered as an important effective parameter. To help researchers about sensing the water quality and maintain the acceptances of its various parameters we are stands for the agreement of this project.

1.2 Existing System

In our most reliable water purifying system, there used the ultra-violate ray to purify the water. There some refining tools are used for filtration of the non-dissolvable elements of the water. But the system hasn't the ability to declare the measurement of factors which are responsible for water quality.

1.2.1 Limitation of the Existing System

Although the ultra-violate radiation has the ability to purify water, but there uncontrolled radioactive effect harmful for the environment. Most of the case, firstly we have to measure the amount of the various factors so that we can ensure how much filtration and radioactive purification are required to achieve standard quality.

1.3 Project Objectives

The major objective of this project is to help researchers about sensing the water quality and maintain the acceptances of its various parameters.

1.4 Contributions

We have to design and implement the sensor arrangement on the circuit board. After a successful gain of the reading of the sensor data, we have to process the sensor data to form readable in the generic parameter unit.

Chapter-2

Literature Review

2.1 Methods and Analysis

On the availability of some wonderful water sensor device, whose can be interfaced with microcontrollers such as Arduino ATMEGA32, we decided to develop this interface which combines the features of all available sensor-based reading about water acceptances parameters such as the potential of Hydrogen, dissolved Oxygen, turbidity, temperature, etc.

2.2 Supporting Theories

Many quantitive and qualitative factors of the water help us to manage the quality of the water. Some of them who are used in our project purpose we have described here.

2.2.1 Autoionization of Water:

Hydrogen ions are spontaneously generated in pure water by the dissociation (ionization) of a small percentage of water molecules. This process is called the autoionization of water:

$$H_2O \rightleftharpoons H^+ + OH^-$$

As shown in the equation, dissociation makes equal numbers of hydrogen (H^+) ions and hydroxide (OH^-) ions. While the hydroxide ions can float around in solution as hydroxide ions, the hydrogen ions are transferred directly to a neighboring water molecule to form hydronium ions (H_3O^+). So, there aren't really H^+ ions floating around freely in the water. However, scientists still refer to hydrogen ions and their concentration as if they were free-floating, not in hydronium form – this is just a shorthand we use by convention. So, the concentration of hydrogen ions produced by dissociation in pure water is 1×10^{-7} M (moles per liter of water).

2.2.2 Acid and Base:

Solutions are classified as acidic or basic based on their hydrogen ion concentration relative to pure water. Acidic solutions have a higher H^+ concentration than water (greater than 1×10^{-7} M), while basic (alkaline) solutions have a lower H^+ concentration (less than 1×10^{-7} M).

2.2.3 Potential of the H+ (pH):

Typically, the hydrogen ion concentration of a solution is expressed in terms of pH. pH is calculated as the negative log of a solution's hydrogen ion concentration: $\mathbf{pH = -\log_{10} [H^+]}$.

2.2.4 The pH scale:

The pH scale is used to rank solutions in terms of acidity or basicity (alkalinity). Since the scale is based on pH values, it is logarithmic, meaning that a change of 1 pH unit corresponds to a ten-fold change in H^+ ion concentration. The pH scale is often said to range from 0 to 14, and most solutions do fall within this range, although it's possible to get a pH below 0 or above 14. Anything below 7.0 is acidic, and anything above 7.0 is alkaline, or basic.

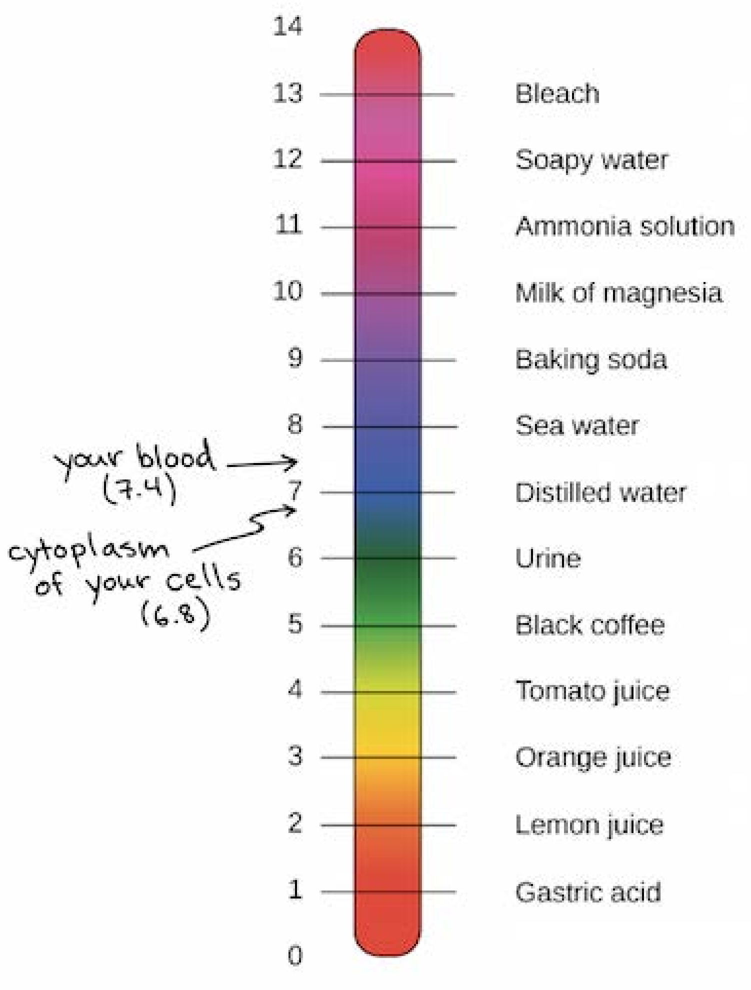

Image modified from "Water: Figure 7," by OpenStax College, Biology, CC BY 4.0. Modification of work by Edward Stevens.

2.2.5 Optimum Water Temperature:

The sweating response in cold water differs significantly compared to other water temperatures. The water temperature of 16°C, as in cool tap water, is the most optimum point for acquiring hydration in dehydrated athletes or other subjects. As well as it's permitted in the range of 5°C to 58°C.

2.2.6 Turbidity of the Water:

Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in the air. The measurement of turbidity is a key test of water quality. [Wikipedia].

Governments have set standards on the allowable turbidity in drinking water. In the United States, systems that use conventional or direct filtration methods must not have turbidity higher than 1.0 nephelometric turbidity units (NTU) at the plant outlet and all samples for turbidity must be less than or equal to 0.3 NTU for at least 95 percent of the samples in any month. Systems that use filtration other than the conventional or direct filtration must follow state limits, which must include turbidity at no time exceeding 5 NTU. Many drinking water utilities strive to achieve levels as low as 0.1 NTU. The European standards for turbidity state that it must be no more than 4 NTU. The World Health Organization establishes that the turbidity of drinking water should not be more than 5 NTU, and should ideally be below 1 NTU. [01]

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01. http://www.lenntech.com/turbidity.htm#ixzz3R3yPreK7

Chapter-3

Proposed System

3.1 System Analysis

The Merriam-Webster dictionary defines system analysis as the process of studying a procedure or business in order to identify its goals and purposes and create systems and procedures that will achieve them in an efficient way. Another view sees system analysis as a problem-solving technique that breaks down a system into its component pieces for the purpose of studying how well those component parts work and interact to accomplish their purpose.

3.2 Overview of the Proposed System

On the availability of some wonderful water sensor device, whose can be interfaced with microcontrollers such as Arduino ATMEGA32, we decided to develop this interface which combines the features of all available sensor-based reading about water acceptances parameters such as the potential of Hydrogen, dissolved Oxygen, turbidity, temperature, etc.

3.3 Feasibility Study

A feasibility study is an analysis of how successfully a project can be completed, accounting for factors that affect it such as economic, technological, legal and scheduling factors. Feasibility analysis (FA, also called feasibility study) is used to assess the strengths and weaknesses of a proposed project and present directions of activities which will improve a project and achieve desired results.

However, the Dissolved oxygen sensor is not available in our country yet, so that other equipment will be delivered within the project time and we expect that, we will have to succeed in interfacing these all sensor features within a single device.

3.4 Requirement Analysis

After analyzing the data collected, we formulated a number of requirements namely user requirements, system hardware, and software attribute. These were grouped as functional and non-functional.

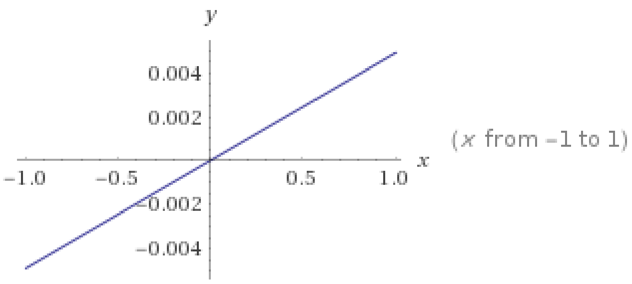
3.4.1 Non-Functional Requirements

- pH electrode E201-C BNC with the calibrate module.
- Waterproof DS18B20 Digital Temperature Sensor.
- Water Turbidity Sensor for Arduino SEN-00205.
- Dissolved Oxygen Sensor.
- Arduino UNO3 with ATMEGA-328P U microcontroller.
- Connecting Jumper wares, etc.

3.4.2 Functional Requirements

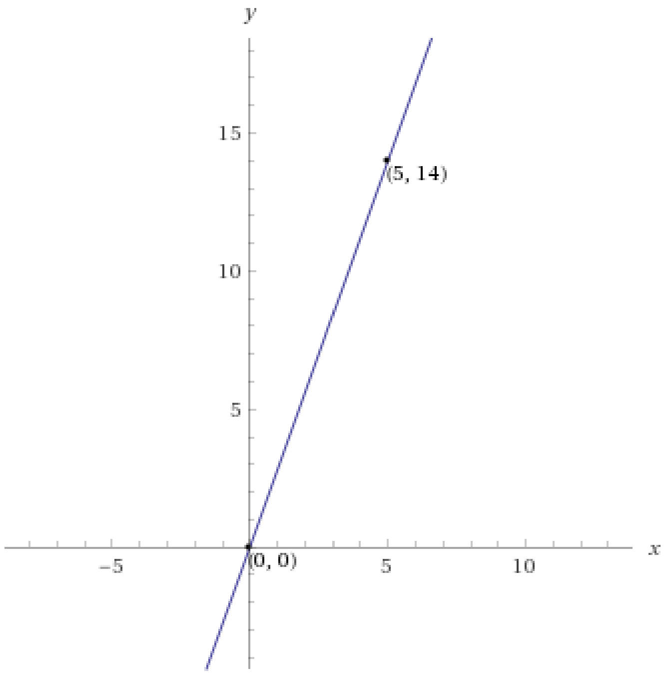
The usage of library function resolves the requirement of single wire temperature reading through the digital temperature sensor. On the other hand, because of analog reading directly as voltage return, we have to process the reading data.

First of all, as the input V_{CC} is 5V we have to process resultant data to an analog voltage in range 0.0V to 5.0V. So that, the defining the curve we have voltage

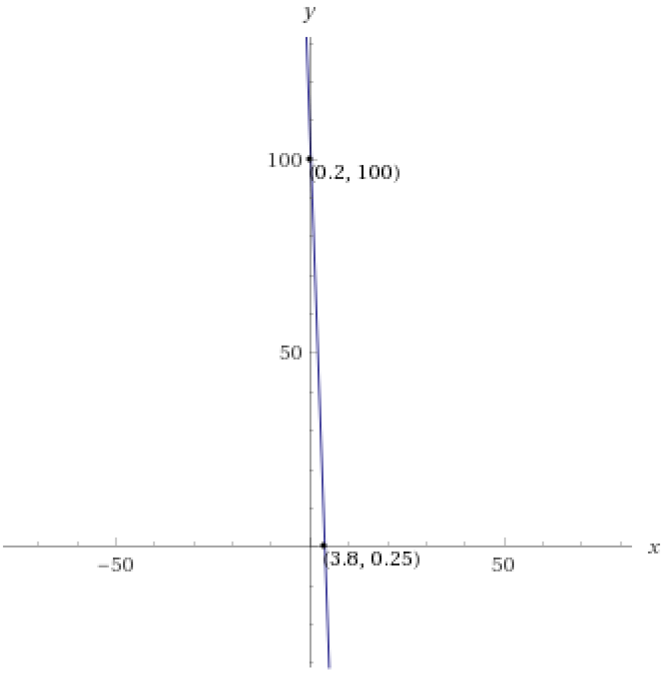


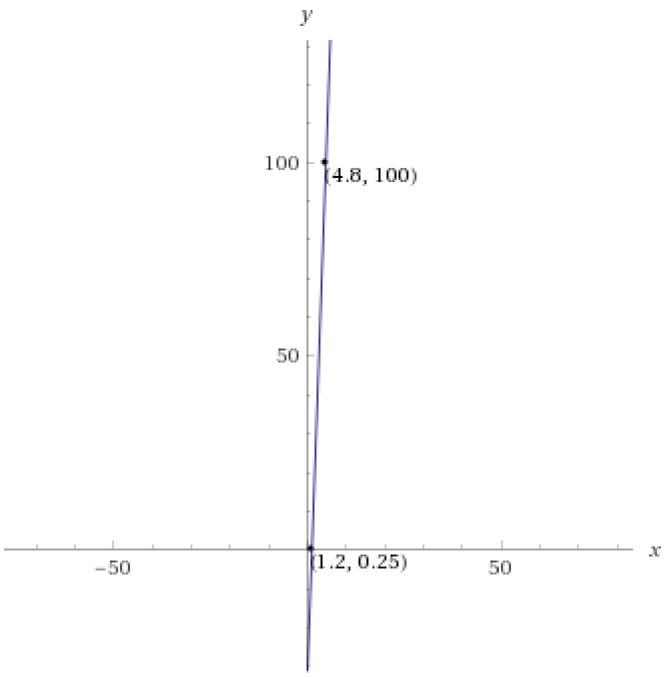
$\boldsymbol{V = 5 \times {}^{x}\!/_{1023}}$.

Then, we have to process the pH reading voltage with the range of pH scale. pH scale defined in the range of 0 to 7. We calibrate the module response within the range of voltage 0.0V to 5.0V corresponding the pH scale. Solving the straight line, $\boldsymbol{5y - 14x = 0}$ we can find the value of y as the value of pH. So that, solving the curve we have pH value **pH =** $\boldsymbol{14 \times {}^{x}\!/_{5}}$.



Then, we have to process the turbidity reading voltage with the range of NTU scale. NTU standards scale with acceptable water defined within the range of 0.25 to 100. Our turbidity module response within the range of voltage 3.8V downward to 0.2V corresponding the NTU scale. Solving the straight line, ***27.7083 x + y = 105.542*** we can find the value of y as the value of turbidity in NTU standards.





But, the problem is the slope of the curve is downward. To simplify, we can resample the resultant voltage by subtracting from 5. Now the range is flipped by π and the slope become upward. So that, the solving the curve ***y - 27.7083 x = -33***, we have Turbidity value **Tr = *27.7083 x - 33***.

3.5 System Design

Arduino UNO-3 have 14 pins for digital I/O and also 8 pins for analog I/O. It also includes the supply of 3.3 to 5-volt potential DC power with ground connection. With proper 5v potential, we have to interface only one analog pin for a turbidity sensor, one or two analog pins for pH electrode and only one pin for the temperature sensor. To ensure one wire output from the temperature sensor, we have to use the resistance of 4.7 kΩ. Then we have to process the sensor data to form readable in the generic parameter unit.

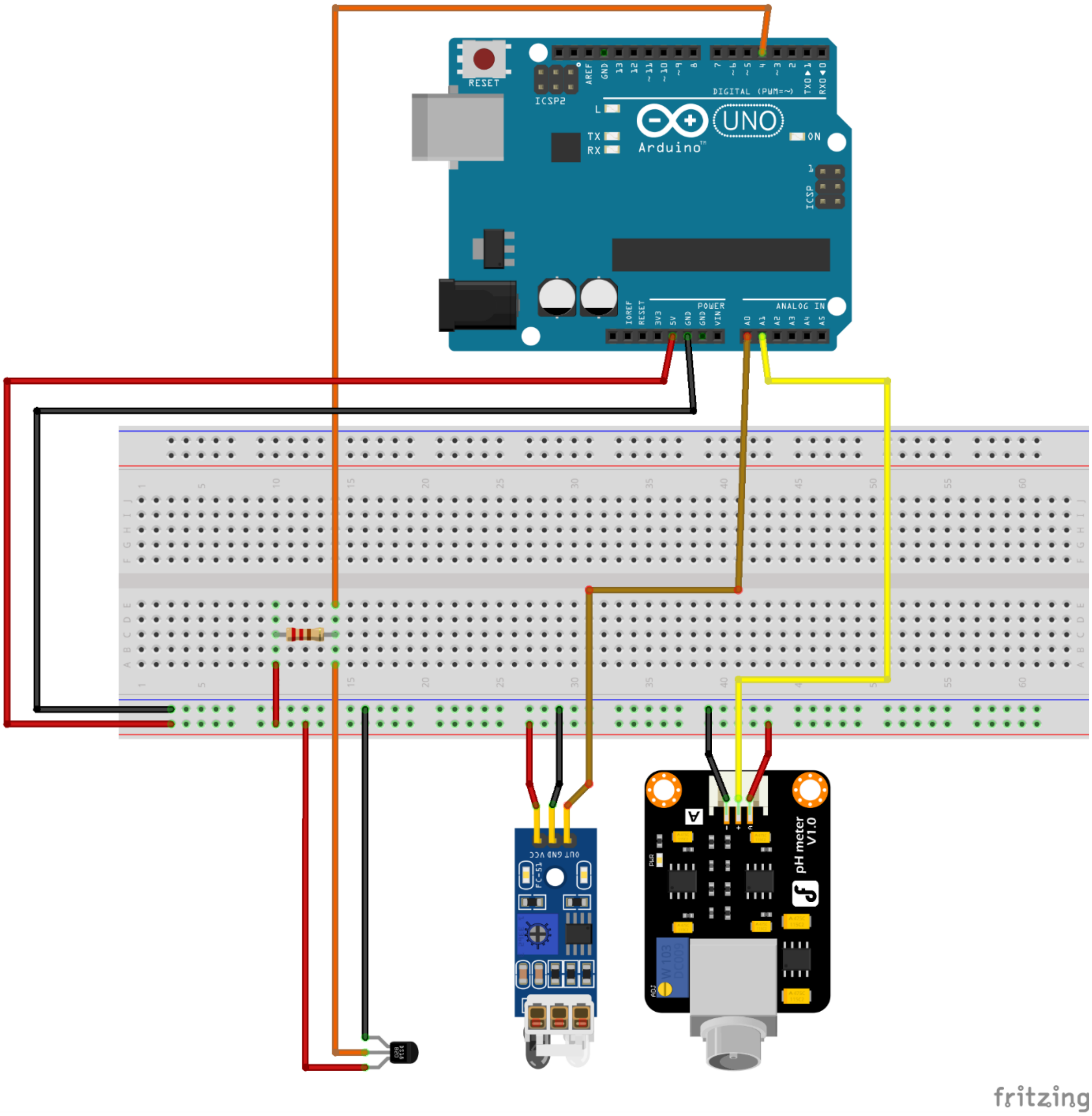


Figure: The Designed Circuit Diagram

Chapter 04

Conclusion

4.1 Outline

After successful implementation of our system, now scope for testing the system. Without testing and required debugging, any implementation is not suitable for applying in the actual solution. So, our system is now under testing.

4.2 System Testing

Our testing is completed within several days from starting the implementation and after the full implementation. Firstly the system tested with non-functional requirements. Then we have tested with functional requirements. Then we have to report our observation and test result to analyze our expectation and performance.

4.3 Analysis of Test Result

Our system gives the data within the testing sample. We used a basic solution who gives pH over than 9.56 then we used acidic buffer to neutralize the whole solution. The resultant output decreased till 4.4 that means the buffer works fine as we expected. Then we use Acidic solution (Lemon Juice) that gives about 2.5 in the reading of pH.

On the other hand, the fresh purified water gives turbidity of 0.3 NTU. Within continuous mixing the sample turbidity from clay and sand it increases up to 86 NTU. It means this sensor also gives expected output.

The temperature sensor also gives required output such it gives data in two types of the unit, the Fahrenheit and the Celsius. As we increase the temperature of the system, both units regulate as we expected.

4.5 Summary

The project is now on complete to assist the researchers in sensing the water quality and maintain the acceptances of its various parameters. In the next time, we expect this project gives feeds on our sensor-based water solution, and it will give us inspiration for a further new research project for another quality management system beyond us.