

Micro Controller Based Ph Meter using magnetic stirrer

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Abstract: A pH Meter is an electronic device which is used for measuring the pH. The pH is either the concentration of Hydrogen ions in an aqueous solution or the active number of Hydrogen ions in an aqueous solution. The pH scale can measure that how acidic or basic a solution is. The pH scale has range of from 0 to 14. A pH 7 of solution is neutral; A pH less than 7 of the solution is acidic. A pH greater than 7 of solution is basic. pH is defined as the negative logarithm of the hydrogen ion concentration [2]. Using digital pH meter we get the numerical value of pH with more accuracy where as in conventional methods we get only indication that the solution is alkaline or base. As it gives the exact number of pH so it is easy to maintain the solution at neutral level. Also it gives the accuracy up to 0.01 %. In this work we used a magnetic stirrer or mixer which is employed for rotating the magnetic field for stirring the solution while sensing the hydrogen ion concentration.

Keywords: Hydrogen ions, Magnetic stirrer, pH Sensor, pH, pH meter

I. Introduction

While measuring the pH by pH paper the problem occurred that we cannot measure the accurate pH value using that pH paper. The paper will only show that whether the solution is acidic or base. So in industry or in water treatment plant the pH is not maintained on natural. In the process of research of medicine on a disease the concentration of pH is very important. The pH measuring techniques available previously are pH paper method , analog pH meter, Antimony-Electrode Method, Quinhydrone-Electrode Method, is not able to give the exact pH value of the aqueous solution. [8]

The purpose of the device micro controller based pH meter is to measure the pH meter accurately up to 0.01% digitally. In order to maintain the solution neutral it is important to know the solution behavior and the pH value of solution. There are some conventional methods of pH measuring like pH paper or the electrode method or the analog pH meter, but we do not get the perfect value of pH using these methods. So we are going with the digital pH meter which overcome the limitations of conventional pH measuring methods.

II. Measurement Of Ph

In our day to day life almost all process contains the use of water, so it is necessary of measurement of pH. The living things like human body, growth of the tree/plant is very much dependent on proper or balanced pH. A pH is defined as the negative logarithm of the hydrogen ion concentration $[H^+]$ [2]. This value ranges from 0pH to 14pH. For acidic, if the values is below 7 and if the value is above 7 is denoted as base or alkaline. Since 7pH is the center of the measurement scale, it is neither acidic nor basic therefore it is called as neutral. For human body the neutral pH is more reliable[4]. Also most of the industries use the neutral pH whereas some of the industries use the concentration of pH depending on the application that is acidic or alkaline (base). It is express mathematically as:

$$pH = -\log[H^+] \quad (1)$$

Where: $[H^+]$ is hydrogen ion concentration in mol/L. A change of one pH unit represents a 10- fold change in concentration of hydrogen ion. In a neutral solution, the $[H^+] = 1 \times 10^{-7}$ mol/L.

this represent a pH of 7

$$pH = -\log [1 \times 10^{-7}] \quad (2)$$

$$= -[\log 1 + \log 10^{-7}] \quad (3)$$

$$= -[0 + -7] = 7.0 \quad (4)$$

2.1 Measuring pH Using Different Methods

2.1.1 Measuring pH Using An Indicator

The method involves preparing pH test paper which is soaked in the indicator, then immersing the paper in the test liquid and comparing its colour with the standard colour. This method is simple, but not the accurate. The Error may occur due to high salt concentration in the test liquid. The another Error can occur due to the temperature of the test liquid[8].

2.1.2 Hydrogen-Electrode Method

A hydrogen electrode method is made by adding platinum plate. It is placed in the test solution and an electric charge is applied to the solution and the solution is saturated with hydrogen gas. The electrode potential is measured between platinum black electrode and silver chloride electrode. This gives the potential which is inversely proportional to pH of the solution.

When the solution of Quinhydrone is added to a solution, it separates into hydroquinone and quinone. Because quinone's solubility varies depending on the pH value of the solution, pH can be determined from the voltage between a platinum and reference electrode. Although this method is simple, it is not popularly used today, because it does not work when oxidizing or reducing substances are involved[8].

2.1.3 Antimony-Electrode Method

This method involves immersing the tip of a polished antimony rod into a test solution, also immersing a reference electrode, and measuring pH from the difference in potential between them. This method was once widely used because the apparatus is sturdy and easy to handle. However, its application is now quite limited because results vary depending on the degree of polish of the electrode, and reproducibility is low[8].

2.1.4 Glass-Electrode Method

The glass electrode method uses two electrodes, a glass electrode and reference electrode, to determine the pH of a solution by measuring the voltage (potential) between them. This method is the one most commonly used for pH measurement, since the potential quickly reaches equilibrium and shows good reproducibility, and because the method can be used on various types of solutions, with oxidizing or reducing substances having very little impact on the result [8].

III. Proposed Method For Measuring The Ph

Water is the main part of basic human needs. Pure water is clear and colourless because it is made up by the combination of one oxygen and two hydrogen atoms. But at present many water sources have contaminants. Water pollution is the contamination of water bodies. To determine the rate of water pollution, the value of the pH in the water should be reviewed. The measurement of pH can be made in variety of ways such as by using pH paper, colorimeter and also pH meter. A pH meter is always recommended for precise and continuous measuring but existing pH meter probe is placed in the liquid when taking the result. The probe normally is called as pH electrode. The operation is similar with a hydrogen electrode within the range between 0.00pH to 14.00pH where the alkali error affects the reading. A pH glass membrane will become dehydrated and will reduce the normal service life of the pH sensors. The pH electrode is very sensitive and do need a protection in order to make it to be durable

IV. Design And Implementation

The pH sensor which is placed in the solution will sense the hydrogen ion concentration. The pH sensor will generate the voltage in terms of millivolts. This millivolts is given to the op-amp amplifier. The op-amp amplifier will amplify the voltage state and give it to the ADC. The ADC will convert the signal to digital form and give it to the microcontroller. The microcontroller will calculate the pH value according to the formula $- \log[H^+]$ and display the result on LCD display. The System development has two parts one is hardware development and second is software development.

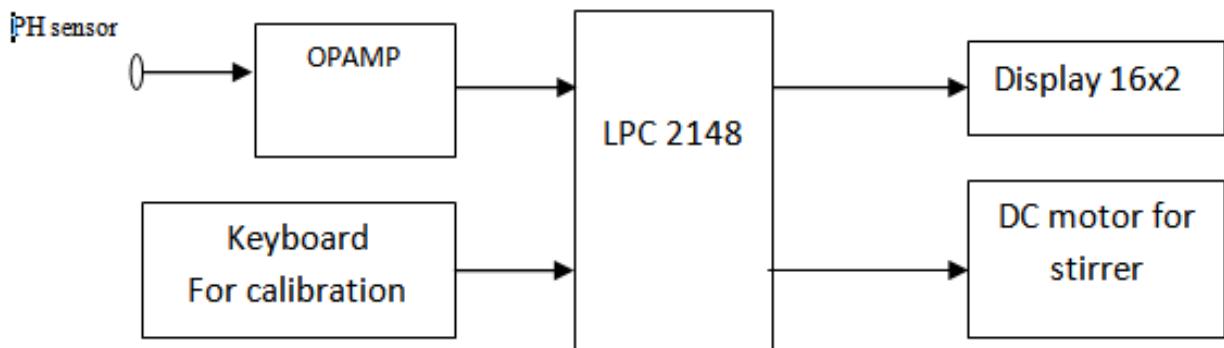


Figure 1. Block Diagram of pH Meter

4.1 Hardware Development

4.1.1 LPC 2148 Micro controller

The LPC2142/2148 microcontrollers are based on a 32/16-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combines the microcontroller with 64 kB and 512 kB of embedded high-speed flash memory. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty.

4.1.2 pH Sensor

A pH measurement loop is essentially a battery where the positive terminal is the measuring electrode and the negative terminal is the reference electrode. The measuring electrode, which is sensitive to the hydrogen ion, develops a potential (voltage) directly related to the hydrogen ion concentration of the solution. The reference electrode provides a stable potential against which the measuring electrode can be compared.

The pH sensor components are usually combined into one device called a combination pH electrode. The measuring electrode is usually glass and quite fragile. Recent developments have replaced the glass with more durable solid-state sensors. The preamplifier is a signal-conditioning device. It takes the high- impedance pH electrode signal and changes it into a low impedance signal which the analyzer or transmitter can accept. The preamplifier also strengthens and stabilizes the signal, making it less susceptible to electrical noise. The sensor's electrical signal is then displayed. This is commonly done in a 120/240 V ac-powered analyzer or in a 24 V dc loop-powered transmitter. Additionally, the analyzer or transmitter has a man machine interface for calibrating the sensor and configuring outputs and alarms, if pH control is being done.

4.1.3 pH Measurement

pH is defined as follows: the lower-case letter "p" in pH stands for the negative common (base ten) logarithm, while the upper-case letter "H" stands for the element hydrogen. pH is an important parameter to be measured and controlled. The pH term translates the values of the hydrogen ion concentration - which ordinarily ranges between about 1 and 10×10^{-14} gram-equivalents per litre - into numbers between 0 and 14. On the pH scale a very acidic solution has a low pH value such as 0, 1, or 2 while a very basic solution has a high pH value, such as 12, 13, or 14 which corresponds to a small number of hydrogen ions. A neutral solution such as water has a pH of approximately equal to 7.

The circuit path from one electrode contact, through the glass barrier, through the solution, to the other electrode, and back through the other electrode's contact, is one of extremely high resistance. The other electrode (called the reference electrode) is made from a chemical solution of neutral (7) pH buffer solution (usually potassium chloride) allowed to exchange ions with the process solution through a porous separator, forming a relatively low resistance connection to the test liquid.

4.1.4 Magnetic Stirrer

A magnetic stirrer or magnetic mixer is a laboratory device that employs a rotating magnetic field to cause a stir bar (also called "flea") immersed in a liquid to spin very quickly, thus stirring it. The rotating field may be created either by a rotating magnet or a set of stationary electromagnets, placed beneath the vessel with the liquid. Magnetic stir bars work well in glass vessels commonly used for chemical reactions, as glass does not appreciably affect a magnetic field. A stir bar is the magnetic bar placed within the liquid which provides the stirring action. The stir bar's motion is driven by another rotating magnet or assembly of electromagnets in the stirrer device, beneath the vessel containing the liquid

4.1.5 DC motor

This DC or direct current motor works on the principle, when a current carrying conductor is placed in a magnetic field; it experiences a torque and has a tendency to move. The DC motor used in the pH meter is to control the stirrer speed. The DC motor does not control the speed directly and so we have made an arrangement that the two permanent magnets are placed on the shaft of the motor. As the shaft rotates the permanent magnet as well as the stirrer magnet will also rotate and the aqueous solution is continuously stirred.

4.2 Software Development

Interfacing of pH sensor is done with microcontroller. The pH sensor calibrated with reference to standard resistor value. Calibration process is as follows

1. Turn the pH meter on and allow adequate time to warm up.
2. Select two pH buffers that bracket the expected sample pH. The first buffer should be pH 7.00 (zero point adjustment) and the second buffer should be near the expected sample pH (pH 4 or pH 9.21). If you will

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- measure both acidic and basic samples, and only perform one pH calibration, you should use a multi-point calibration.
3. Before starting calibration, be sure the sensor and the buffer solution are at the same temperature. If not, allow time for temperature equilibration.
 4. Pour the necessary amount of buffer solutions into individual glass beakers. Buffer solutions will remain stable in a glass beaker for a maximum of 2 hours. Note: To minimize the risk of contamination, calibrations should never be carried out in the storage container. Close the buffer containers promptly to avoid carbon dioxide absorption. Do not pour used buffer back into the storage container. Discard it.
 5. Place the electrode into the first buffer. When the reading is stable, set the pH meter to the pH value of the first buffer at the measured temperature.
 6. Detection of fast stabilized reading Between buffers, rinse the electrode with distilled water and then with the next buffer. If you, for some reason, not want to rinse the pH electrode with the next buffer; Rinse the electrode with distilled water and gently blot it dry with a lint-free tissue. Avoid rubbing or wiping the electrode bulb.
 7. Repeat step 3 for the next buffer.
 8. When the pH meter calibration is done, rinse the electrode and place into the sample and make your pH measurement.

V. Conclusion

During this project development, various new knowledge were learned. This project work indeed is an add-on which helps the existing knowledge and to prove the theory that we have learned in the classroom.

After the development of the project we get the numerical value of the pH and also we know whether the solution is acidic or base. Also the accuracy of the pH meter is of 0.01% which is very useful in pharmaceutical companies, soil testing and also in research or developing the new medicine or fertilizer. H/W implementation is almost finished and software is in development stage and 75% of project is complete.

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