THE DESIGN/ANALYSIS OF OPTOELECTRONIC pH METER

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DEDICATION

Especially dedicated to my adorable parents
Ku Osman Bin Ku Hasan and Rosnah Bt Osman
Your love, encouragement and counsel for me are really appreciated

Thankfulness to beloved family members
Faizul, Fatin,and Fekree
Their supports really assist me a lot

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Thank you for being a good company to me

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ABSTRACT

A pH can be defined as the negative logarithm of the hydrogen ion concentration [H^+]. This value ranges from pH 0 to 14 pH. For acidic, the values is below 7pH meanwhile the value that is above 7pH is determine 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. The pH of water is determine solubility which mean as an amount that can be dissolve in the water and also to determine the biological ability which mean as an amount that can be utilized by aquatic life of the chemical constituents such as nutrients and also heavy metal. This project is about design and analysis of optoelectronic pH meter. This project is using infrared for transmitting and receiving the signal. To determine the suitable frequency and device for this project, several testing are conducted based on literature review. The reaction of infrared on liquids with different pH levels the absorbance, scattering and also reflectance that may affected.

ABSTRAK

Nilai pH dapat ditafsirkan sebagai logaritma negatif daripada kepekatan ion hidrogen [H^+]. Nilai pH adalah dari pH 0 hingga pH 14. Nilai asid adalah di bawah nilai pH7 manakala nilai melebihi pH7 dikenali sebagai alkali. Oleh kerana nilai pH7 berada ditengah-tengah skala pengkuran maka ia diklasifikasikan sebagai neutral. Nilai pH air menentukan kelarutan cecair yang bermaksud sebagai jumlah larutan yang boleh larut didalam air dan juga menentukan kemampuan biologi yang bermaksud sebagai suatu jumlah yang boleh dimanfaatkan oleh kehidupan air dari unsure-unsur kimia seperti nutrisi dan juga logam berat. Projek ini adalah tentang mereka serta menganalisis tentang optoelektronik pH meter. Projek in menggunakan cahaya inframerah untuk menghantar dan menerima isyarat. Untuk mengenalpasti frekuensi serta peralatan yang diperlukan untuk projek ini, ujikaji dijalankan berdasarkan tinjauan kajian. Hasil tindakbalas sinar inframerah terhadap cecair dengan nilai pH yang berbeza adalah serapan,pemecahan dan pantulan.

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I.R	-	Infrared
pH	-	Potential of Hydrogen
Hz	-	Hertz
kHz	-	Kilo Hertz
MHz	-	Mega Hertz
THz	-	Tera Hertz
GHz	-	Giga Hertz
TV	-	Television
LED	-	Light Emitter Diode

CHAPTER 1

INTRODUCTION

1.0 Introduction

The process that has been containing water must need for a pH measurement. Humans and animal rely on internal mechanism in order to maintain the pH level in blood. Normally the blood that has been flow in our vein must have between7.35 to 7.45 for the pH value [1].

In agriculture, the soil and the fertilizer pH value must be different and it is depend on the type of the plant. In order to have the right pH, farmer will cooperate with the department of agriculture such as Mardi, Ministry of Agriculture and Agro-Based Industry Malaysia and etc to improve the quality of the crops. The quality of the plant will be high quality if the soil can be maintained at the optimal pH.

Rain water is naturally acidic which mean it must be below than 7.0 pH. It normally is pH 5.4 [2], but the pH value is increases due the pollutants in the atmospheric. The combination of the rain water and the element such as the releases gases will change the composite of the rain water and became more acidic. The other pH applications include reverse osmosis, cooling water control, prevent shampoo from sting

eye and etc. So pH is important and necessary thing in our daily life. The equipment that can be use in order to measure the pH are pH paper, indicator, colorimeter and also pH meter.

This project is about the Optoelectronic pH meter. It involves the analysis and also investigation of effects of various pH values infrared ranges. It based on pH that depends to the changes of absorbance or luminescence of certain indicator molecules. The importance things to investigate are the pH, acid, base and also infrared transmitter and infrared receiver unit. The experimentation with various acid and base will be adopted in the procedure to obtain the value of pH.

The development of this project will be focusing on the pH measurement in daily uses such as to determine the pH value of osmosis drinking water by using the radiation of the infrared. The light will scattered, absorbance and also reflectance. The receiver will receive the low balance of the infrared light to analyze and will display the observe measurement value.

1.1 Problem Statement

Water is the main part of basic human needs. In vapor, liquid or solid form, water is covers more than 70% of the earth surface [3]. Human beings itself is consist of two-third of the water in their body. Pure water is clear and colorless 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. Water pollution affects plants and organisms living in these bodies of water. The effect is damaging not only to individual species and populations, but also to the natural biological communities. Water pollution occurs when pollutants are discharged directly or indirectly into water bodies without adequate treatment to remove harmful compounds.

To determine the rate of water pollution, the value of the pH in the water should be review. The measurement of pH can be made in variety of ways such as by using pH paper, colorimeter and also pH meter. The pH paper is commonly use for small volume measuring. It cannot be used for continuous monitoring of the process meanwhile the colorimeter can be used to grab sample measuring but not for continuous online measuring.

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 of 0.00pH to 12.00pH where the alkali error affects the reading [4]. 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. Existing pH meter in the market are quite expensive for the users. From the previous project, the sensor for detecting the liquid to measure the pH is not functional.

1.2 Objective

The objectives are to learnt and study about the effects of infrared towards any types of liquid and its relationship, learnt about the light propagation techniques (infrared signal) in different media and also learnt about the chemistry associated with the use of electronic device. Introduce the possibilities for setting acquire knowledge and hands on experience in constructing and understanding of the transmitter and receiver via infrared radiation and the other dealing with understanding and repairing an existing unit with help of reverse engineering. Apply the theory of the characteristic of infrared such as absorption and scattering towards chemical to verify its reaction so that the result will analyze to produce the pH sensor as a probe, so that the pH meter that will be produce only use a sensor as a probe.

1.3 Scope of the project

Several scopes that need to be considered in this project to make sure this project successful are:

a) Study and research - Find more information that related with this project. The entire for this project can be divided in two sections; software and hardware design.

b) Hardware design - Find more sources of material to complete this project. The main criteria in deciding on what to use were size, performance, features and price. Design the circuit that included all the necessary electronic components to make sure this project completely functioning.

c) Software design – Find some sources of software to get the expected output. Make sure the software is suitable with the hardware.

1.4 Thesis Outline

This thesis represents five chapters. The following is the outline of the Design/ Analysis of Optoelectronic pH meter project in chapter by chapter. Chapter I is discussing about the overview of the project such as introduction, objective, problem statement and scope of the project.

Chapter II is describes about the research and information about the project. Every facts and information which is found through the journals or other reference will be inserted and to be as a reference due to find the suitable methods for this project. The literature review and the circuit development of the project will be using two types of software which is Multisim 2001 and also Proteus 7 Professional.

Chapter III is discussing about the project methodology used in this project such as data capture and comparison process. All these methodology should be followed for a better performance.

Chapter IV is describes about the project findings such as result and analysis of the electronics component which is optoelectronic that been using infrared. The result is presented by tables, graphs and figures.

Finally, Chapter V is about the discussion and conclusion achieved in this project.

CHAPTER 2

LITERATURE REVIEW

2.0 Literature Review

This chapter will be focusing on the infrared reactions towards acid and base. This chapter also will focus about the value of the frequency and type of infrared that will be chosen in this project. Besides that the previous studies or project that has been done by previous researcher will also be discussed.

2.1 Potential of Hydrogen (pH)

Almost all process that has been containing water has a need of pH measurement. The living things depend on a proper pH to sustain life. A pH can be defined as the negative logarithm of the hydrogen ion concentration [H^+]. This value ranges from 0 to 14pH. For acidic, the values is below 7 pH meanwhile the value that is above 7pH is determine 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 [4].

It is express mathematically as:

$$pH = -\log[H^+] \qquad \textbf{(2.1)}$$

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

$$pH = - \log [1 \times 10^{-7}]$$
$$= -[\log 1 + \log 10^{-7}]$$
$$= -[0 + -7]$$
$$= 7.0$$

The table below represents the relative of $[OH^-]$ and $[H^+]$ Mol/Liter Concentrations [4]. From this table, it can determine the type and the value of pH by using the simple calculation as above.

Table 2.1: The relative of $[OH^-]$ and $[H^+]$ Mol/Liter Concentrations.

	$[OH^-]$ concentration (mol/l)	pH	$[H^+]$ concentration (mol/l)		
1×10^{-14}	0.00000000000001	0	1	1×100	
1×10^{-13}	0.0000000000001	1	0.1	1×10^{-1}	
1×10^{-12}	0.000000000001	2	0.01	1×10^{-2}	
1×10^{-11}	0.00000000001	3	0.001	1×10^{-3}	Increasing acidity
1×10^{-10}	0.0000000001	4	0.0001	1×10^{-4}	
1×10^{-9}	0.000000001	5	0.00001	1×10^{-5}	
1×10^{-8}	0.00000001	6	0.000001	1×10^{-6}	
1×10^{-7}	0.0000001	7	0.0000001	1×10^{-7}	Neutral
1×10^{-6}	0.000001	8	0.00000001	1×10^{-8}	
1×10^{-5}	0.00001	9	0.000000001	1×10^{-9}	
1×10^{-4}	0.0001	10	0.0000000001	1×10^{-10}	Increasing basicity
1×10^{-3}	0.001	11	0.00000000001	1×10^{-11}	
1×10^{-2}	0.01	12	0.000000000001	1×10^{-12}	
1×10^{-1}	0.1	13	0.0000000000001	1×10^{-13}	
1×100	1	14	0.00000000000001	1×10^{-14}	

2.1.1 pH Indicator

A pH indicator is a halochromic chemical compound that is added in small amounts to a solution so that the pH (acidity or alkalinity) of the solution can be determined easily.

Hence a pH indicator is a chemical detector for hydronium ions (H3O+). Normally, the indicator causes the color of the solution to change depending on the pH. pH indicators themselves are frequently weak acids or bases. When introduced into a solution, they may bind to H+ (Hydrogen ion) or OH- (hydroxide) ions. The different electron configurations of the bound indicator cause the indicator's color to change. Because of the subjective determination of color, pH indicators are susceptible to imprecise readings. For applications requiring precise measurement of pH, a pH meter is frequently used [5]. The pH indicators are frequently employed in titrations in analytic chemistry and biology experiments to determine the extent of a chemical reaction. Tabulated below are several common laboratory pH indicators. Indicators usually exhibit intermediate colors at pH values inside the listed transition range [4]. For example, phenol red exhibits an orange color between pH 6.6 and pH 8.0. The transition range may shift slightly depending on the concentration of the indicator in solution and on the temperature at which it is used.

2.1.2 pH Meter

A pH meter is an electronic instrument used to measure the pH (acidity or basicity) of a liquid (though special probes are sometimes used to measure the pH of semi-solid substances, such as cheese). A typical pH meter consists of a special measuring probe (a glass electrode) connected to an electronic meter that measures and displays the pH reading. The pH probe measures pH as the concentration of hydrogen ions surrounding a thin-walled glass bulb at its tip [4]. The probe produces a small voltage (about 0.06 volt per pH unit) that is measured and displayed as pH units by the meter. For more information about pH probes, see glass electrode. The meter circuit is fundamentally no more than a voltmeter that displays measurements in pH units instead of volts. The input impedance of the meter must be very high because of the high resistance approximately 20 to 1000 MΩ (Mega ohms) of the glass electrode probes typically used with pH meters. The circuit of a simple pH meter usually consists of operational amplifiers in an inverting configuration, with a total voltage gain of about -

17. The inverting amplifier converts the small voltage produced by the probe (+0.059 volt/pH in basic solutions, -0.059 volt/pH in acid solutions) into pH units, which are then offset by 7 volts to give a reading on the pH scale. The pH meters range from simple and inexpensive pen-like devices to complex and expensive laboratory instruments with computer interfaces and several inputs for indicator (ion-sensitive, red ox) [4], reference electrodes, and temperature sensors such as thermo resistors or thermocouples. Cheaper models sometimes require that 25 temperature measurements be entered to adjust for the slight variation in pH caused by temperature. Specialty meters and probes are available for use in special applications, harsh environments, etc. Pocket pH meter are readily available today for a few tens of dollars that automatically compensate for temperature.

2.2 Acid and Alkali

2.2.1 Acid

An acid is a substance that tastes sour that will reacts with metals and carbonates. It turns blue litmus paper to red and the pH is below than 7. The chemical or substance which has the property of an acid will know as acidic [7]. The substance that increases the concentration of the hydronium ion when it dissolved in water is called as Arrhenius acid. The pure water will respect to the acidity and make the concentration of the hydroxide ions is always equal to the concentration of hydronium ions [6].

An Arrhenius base is a molecule which increases the concentration of the hydroxide ion when dissolved in water. The Bronsted acid is an acid base reaction that involves the transfer of a proton. Lewis acid is a reaction with acid base characteristics that do not involve in proton transfer. It is an electron pair acceptor.

A conjugate acid is the acid member, HX, of a pair of two compounds that transform into each other by gain or loss of a proton. A conjugate acid can also be seen