THE DESIGN AND PERFORMANCE ANALYSIS OF PH SENSOR USING IR LED

NUR ATIQAH BINTI MOHD SADIK

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE DESIGN AND PERFORMANCE ANALYSIS OF PH SENSOR USING IR LED

NUR ATIQAH BINTI MOHD SADIK

This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

2022

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : THE DESIGN OF PH SENSOR USING IR LED
Sesi Pengajian : 2021/2022

Saya NUR ATIQAH BINTI MOHD SADIK mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

☐ **SULIT*** (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

☐ **TERHAD*** (Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan.)

☑ **TIDAK TERHAD**

Disahkan oleh:

(TANDATANGAN PENULIS)

Alamat Tetap: 1029-A Kampung Dalam Kedai Buluh, 21070 Kuala Terengganu

Tarikh : 10 JUN 2022

(COP DAN TANDATANGAN PENYELIA)

DR. HANIM BINTI ABDUL RAZAK
Pensyarah Kanan
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Tarikh : 10 JUN 2022

*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I declare that this report entitled “The Design of pH Sensor Using IR LED” is the result of my own work except for quotes as cited in the references.

Signature : .....

Author : NUR ATIQAH BINTI MOHD SADIK

Date : 10 JUN 2022

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering with Honours.

Signature : .....

Supervisor Name : DR HANIM BINTI ABDUL RAZAK

Date : 10 JUN 2022

DEDICATION

Special dedicated to my loving parents, Mohd Sadik Bin Saleh and Wan Mek Binti Wan Muda. Your love, encouragement and continuous support given are appreciated.

Infinity gratitude to my beloved siblings, Anisah, Akmardalia, Azidah, Intanliana, Hasbullah, Hasimah and Haziq Haikal. Their supports risen my motivation.

Big thanks to my supervisor, Dr Hanim Binti Abd Razak. For the guidance and assistance to complete the project. Your kindness will never be forgotten.

ABSTRACT

Every liquid in the world has their own potential hydrogen (pH) value to define their acidity or basicity of aqueous. pH term is widely used in chemistry, biology, and agronomy to measure the concentration of hydrogen ion. Infrared pH sensor is the subject of this project. The concentrate of this design and development will be on pH measurement in everyday applications, such as determining the pH value of lime juice, vinegar, mineral water, etc. The aim is to design and fabricate a pH sensor based on infrared wave and to analyze its performance to achieve optimize results. IR LED will be used as a pH sensor to measure the pH value with 940nm wavelength. IR LED performance will be analyzed when IR LED length varied from 1cm to 10cm and tilted to 0°, 30° and 60°. Arduino Nano will read the sensor then LCD will display the voltage of any types of liquid measured. As a result, the voltage vs pH is inversely proportional where the higher voltage value, the lower pH value. In addition, sensor needs to be placed in parallel orientation (0°) because the infrared absorption is zero if it is in perpendicular orientation (30° & 60°). The sensitivity of pH sensor of this project is 1.1674 V/pH It has a strong response of alkaline solution towards 940nm wavelength due to less infrared absorption of the liquid samples. This project can be used to improve the performance of pH sensor.

ABSTRAK

Setiap cecair di dunia mempunyai potensi nilai hidrogen (pH) mereka sendiri untuk menentukan keasidan atau keasaman akueus. Tumpuan reka bentuk dan pembangunan ini adalah pada pengukuran pH dalam aplikasi harian, seperti menentukan nilai pH jus limau nipis, cuka, air mineral, dll. Tujuannya adalah untuk mereka bentuk dan membuat penderia pH berdasarkan gelombang inframerah dan untuk menganalisis prestasinya untuk mencapai hasil yang optimum. LED IR akan digunakan sebagai sensor pH untuk mengukur nilai pH dengan panjang gelombang 940nm. Prestasi LED IR akan dianalisis apabila panjang LED IR berubah dari 1cm hingga 10cm dan dicondongkan kepada 0°,30° dan 60°. Arduino Nano akan membaca sensor kemudian LCD akan memaparkan voltan sebarang jenis cecair yang diukur. Akibatnya, voltan vs pH adalah berkadar songsang di mana nilai voltan yang lebih tinggi, nilai pH yang lebih rendah. Penderia perlu diletakkan dalam orientasi selari (0°) kerana penyerapan inframerah adalah sifar jika ia berada dalam orientasi serenjang (30°&60°). Kepekaan penderia pH projek ini ialah 1.1674 V/pH Ia mempunyai tindak balas kuat larutan alkali terhadap panjang gelombang 940nm disebabkan oleh penyerapan inframerah yang kurang bagi sampel cecair. Projek ini boleh digunakan untuk meningkatkan prestasi penderia pH.

ACKNOWLEDGEMENTS

My dissertation is dedicated to my family, friends, and supervisor. I owe a great sense of gratitude to my devoted parents, Mohd Sadik Bin Saleh and Wan Mek Binti Wan Muda whose words of encouragement and the words "push for tenacity" resound in my head. My sisters and brothers, Anisah, Akmardalia, Azidah, Intanliana, Hasbullah, Hasimah and Haziq Haikal. They've never left my side and are extremely dear to me.

This thesis is also dedicated to my closest dear friends, Aiman Zhafri, Amira Athirah, Syahirah, Syakila, Najwa and Nadhirah who have been supportive all through the journey. I shall be eternally grateful for everything they have done for me throughout my bachelor's degree programme. They have been my most ardent supporters.

Dr. Hanim Binti Abdul Razak, my supervisor, deserves special thanks for her unwavering support and advice. Throughout the final year project, she was a constant source of inspiration and was always eager to help in any way she could.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

pH	:	Potential of Hydrogen
LED	:	Light Emitted Diode
IR	:	Infrared
H+	:	Hydrogen ion

CHAPTER 1

INTRODUCTION

The overview of the project is dicussed in this chapter that consists of introduction, objectives, problem statement, and scope of project.

1.1 Project Background

Every liquid in the world has their own potential hydrogen (pH) value to define their acidity or basicity of aqueous. pH is a critical metric in a variety of domains, as for instance environmental, biological, industrial, and biomedical sciences [1]. These applications typically require pH sensors that are very reliable and accurate, as well as little maintenance and a long lifespan. pH readings have been investigated using a variety of electrochemical and non-electrochemical approaches. Many electrochemical devices, such as acid-base indicators, paper strips, glass electrodes, and semiconducting systems, have been created for pH testing. However, their

substantial bulk and requirement for regular calibration limit their use [2]. pH measuring accuracy and reliability are critical in a variety of sectors, including chemistry, biology, and environmental studies, as well as food science, human healthcare, and illness diagnosis [3].

The glass-bulb-based electrode, which has also been well-established as a commercial product of great stability and precision (unless in too high/low settings) due to its high selectivity toward protons, is currently the most widely used. However, these devices have some drawbacks, such as a lack of precision when detecting high pH values, as well as measuring aqueous suspensions of organic matter or solutions with low ionic strength. Not only that, but it is also indeed brittle, prone to floating, and prone to alkali mistakes. In high-pressure and high-temperature situations. For some applications, these issues limit the use of glass electrodes [4].

The approaches for overcoming the narrow dynamic range and effectively using pH indicators across a wider range is to use an array of pH indicators, where each indicator is a sensor element, and the overall responses from all sensor elements are used to determine pH. Optical sensors could be a useful choice in certain situations because they are less likely to have these limitations [5].

1.2 Problem Statements

Water is the main part of basic human needs. As well as plants and any other living organisms. In human body, it consists of two-third of water. However, in this era, some of the waters are impurity that may contains harmful compounds, and it gives bad impact to us and our nature. As a result, the ph level in the liquid must be reviewed to evaluate the impact of water pollution.

pH can be measured using a variety of methods, including pH paper, colorimeters, and pH meter. For low volume measurements, pH paper is widely used. It cannot be used for continuous process monitoring; nevertheless, the colorimeter can be used to measure samples but not for continuous online measurements.

A pH meter is always advised for precise and continuous measurement, but when getting the result, The probe of an existing pH metre is inserted into the liquid. A pH electrode is the popular name for the probe. When using a hydrogen electrode in the 0.00pH to 12.00pH range, the alkali error has no effect on the reading [7]. The pH glass membrane will become dehydrated, reducing the pH sensors typical service life. The pH electrode is extremely sensitive and requires care in order to be long-lasting. Therefore, this project is proposed as alternative to improve pH sensor for optimum result.

1.3 Objectives

The objectives of the project are:

a. To design and fabricate a pH sensor based on infrared absorption.

b. To analyze the performance of the pH sensor for optimum result.

1.4 Project Scopes

There are several scopes that must be examined in order for this project to be effective.

i. Sensor:

The pH value will be measured using an IR LED as a pH sensor. It consists of IR LED transmitter and BPW34 Photodiode as a receiver.

ii. Software:

Several software will be used which are Eagle and Arduino IDE.

iii. Microcontroller:

Arduino Nano as a microcontroller due to smaller size and not bulky.

iv. Type of liquids:

Acid: Lime, vinegar, and floor cleaner.

Neutral: Mineral water.

Alkaline: Detergent, body wash, and toothpaste.

v. Parameter / analysis:

- The voltage reaction towards every type of liquid with different pH value.
- The performance of sensor with different length within 1cm to 10cm and if it is tilted in different degree of angle (0º, 30º, and 60º).

CHAPTER 2

BACKGROUND STUDY

This chapter will be focusing on fundamental of Potential of Hydrogen (pH), the research and information related to the project. Every fact and information are gathered through the journal and previous research that have been done by the researchers. The literature review also discussed.

2.1 Potential of Hydrogen (pH)

The pH scale determines how acidic or basic a solution is in the same way that the kilometre measures distance and the hour measures time. It is rated on a scale of 0 to 14. The pH word is made up of two letters: "p" for negative logarithm and "H" for hydrogen. The formal definition of pH is the negative logarithm of hydrogen ion (H+) activity. pH values that less than 7 have acidic properties. Basic characteristics (sometimes known as caustic or alkaline) are demonstrated by pH values greater than

7. Because 7 pH is the middle of the measurement scale, it is neither acidic nor basic and is thus referred to as "neutral" [7].

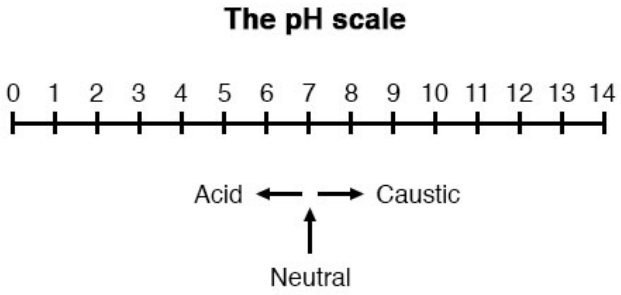

Figure 2.1: pH Scale

The negative common (base ten) logarithm is represented by the lower-case letter "p," while the element hydrogen is represented by the upper-case letter "H."

$$pH = - \log [H+]$$

Hydrogen ion [H+] 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 $[H^+] = 1\ x\ 10^{-7}$ mol/L. It can be proven by:

$$pH = -\log[1\ x\ 10^{-7}]$$

$$= -[\log 1 + log\ 10^{-7}]$$

$$= -\ [\ 0 + (-7)]$$

$$= 7.0$$