Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF COVID-19 PATIENT RESPIRATORY RATE MONITORING DEVICE USING ARDUINO

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Bachelor of Electronics Engineering Technology with Honours

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A project report submitted
in partial fulfillment of the requirements for the degree of
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Sesi Pengajian : 1-2021/2022

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I declare that this project report entitled “Development of Covid-19 Patient Respiratory Rate Monitoring Device using Arduino” is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology with Honours.

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Supervisor Name : PUAN IZADORA BINTI MUSTAFFA

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DEDICATION

To my beloved mother, Zalina Binti Muhamad Said, and father, Rosli Bin Mohd Noor, Siblings, Housemates and My friends, Muhammad Nur 'Aizat Bin Rahmat and Muhammad Afiq Bin Mohamad Alias for encouraging me through this project

and

To my supervisor, Puan Izadora Binti Mustaffa for all the guidances

Thank you for everything.

ABSTRACT

Covid-19 has had a significant impact on many people's lives. Millions of individuals are infected, and millions of people have died as a result of the disease. The virus infects the respiratory system severely. After the lungs have been inflamed, it is difficult to recover. The virus has since mutated, and the infection rate has increased. Various countries' healthcare systems are collapsing as a result of the increasing number of Covid-19 patients. More Covid-19 virus-related research, including healthcare technologies, are being conducted as a result of this. In this study a low-cost respiratory rate monitoring system is described. The system monitors the patients' breathing by using piezoelectric sensors. The sensors are placed on a chest belt with pre-determined size. As the wearer breaths in and out, the sensors measures the pressure of the chest pressing against it. The values obtained indicate the chest expansion and deflation. An Arduino Uno was utilized to read the signal acquired by the piezo sensors. It sends the data can be viewed on the serial plotter. The respiration rate per minute is calculated in the microcontroller and sent to the smartphone via ESP8266 Wi-Fi module to be displayed on the smartphone using Blynk app. The status of the respiration rate i.e. normal and abnormal are displayed when breathing is in these ranges. This work shows another modality to monitor Covid-19 patients.

ABSTRAK

Covid-19 telah memberi kesan yang besar kepada kehidupan ramai orang. Berjuta-juta individu tela dijangkiti, dan berjuta-juta orang telah meninggal dunia akibat penyakit itu. Virus ini menjangkiti sistem pernafasan dengan teruk. Selepas paru-paru telah meradanga, sukar untuk pulih. Virus ini telah bermutasi, dan kadar jangkitan telah meningkat. Sistem penjagaan kesihatan pelbagai negara semakin runtuh akibat peningkatan jumlah pesakit Covid-19. Lebih banyak penyelidikan berkaitan virus Covid-19, termasuk teknologi penjagaan kesihatan, sedang dijalankan akibat daripada ini. Dalam kajian ini sistem pemantauan kadar pernafasan kos rendah diterangkan. Sistem ini memantau pernafasan pesakit dengan menggunakan sensor piezoelektrik. Penderia diletakkan pada tali pinggang dada dengan saiz yang telah ditetapkan. Semasa pemakai menarik nafas masuk dan keluar, penderia mengukur tekanan dada yang menekannya. Nilai yang diperolehi menunjukkan pengembangan dan deflasi dada. Arduino Uno digunakan untuk membaca isyarat yang diperoleh oleh sensor piezo. Ia menghantar data boleh dilihat pada plotter bersiri. Kadar pernafasan seminit dikira dalam mikropengawal dan dihantar ke telefon pintar melalui modul Wi-Fi ESP8266 untuk dipaparkan pada telefon pintar menggunakan applikasi Blynk. Status kadar pernafasan iaitu normal dan tidak normal dipaparkan apabila pernafasan berada dalam julat ini. Kerja ini menunjukkan satu lagi kaedah untuk memantau pesakit Covid-19.

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I'd like to express my gratitude to the staff of Faculty of Electrical and Electronic Engineering Technology, as well as my classmates, lecturers for their cooperation and assistance.

My undying gratitude to my parents and family members for their love and prayers during my studies. To my sister, Auni Nazurah Binti Rosli, I will forever be thankful to your dedication and understanding.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

δ	-	Voltage angle
	-	
	-	
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	-	
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	-	
	-	

LIST OF ABBREVIATIONS

rpm	-	Respiratory rate per minute
EFM	-	Electro Force Microscopy
IoT	-	Internet of Things
kV	-	Kilo Volt
V	-	Voltage
IDE	-	Integrated development environment
LCD	-	Liquid Crystal Display
ADC	-	Analog Digital Converter

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Many patient have to be turned away by the hospital due to the overwhelmingly high number of Covid-19 instances per day. Therefore, self-monitoring is vital to ensure the patients is able to seek medical assistance quickly. The internet of things (IoT) technology included in this monitoring equipment makes it more convenient to monitor a patient's respiration rate per minute from anywhere at any time.

1.2 Problem Statement

Covid-19 viruses attack the respiratory system. By counting the rate of respiratory rate per minute can be used to predict the health of a person. However, it is difficult for anybody to consciously count our breathing intermittently. To rectify these problems, monitoring respiratory rate devices using piezoelectric sensors is introduced. Piezoelectric sensor is quite sensitive but the sensitivity of the sensor gives a lot of benefits if it put the most suitable part on the patient body to detect the pressure of breath of a patient. Subsequently, a design is proposed in this work. The piezoelectric sensors were strategically placed on a belt that would be worn by the patient over the chest. The breathing motion would put pressure on the sensors and thus yield the values to measure the chest expansion and deflation.

1.3 Project Objective

The main aim of this project is to develop a respiratory rate monitoring device that are use to monitor the Covid-19 patient. Specifically, the objectives are as follows:

a) To design a monitoring device for Covid-19 patient using Arduino Uno.

b) To develop a Covid-19 monitoring device that can monitor the patient's respiratory rate and the chest expansion per minute.

c) To implement an automatic monitoring respiratory rate device through the mobile application.

1.4 Scope of Project

The scope of this project are as follows:

a) The Piezoelectric sensor is used to detect the pressure of the chest when the chest expands. The pressure is then be recorded to get the total number of breaths per minute.

b) The Arduino Uno R3 microcontroller then calculates the rate per minute.

c) This Covid-19 monitoring device can display the number of adult patient's respiratory rate per minute and the adult patient's health on a mobile application which via Blynk apps.

d) The display basically will show the parameter of the Piezoelectric sensor which is the movement of the chest as the main total breaths per minute among the adult patient.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter explores and investigates previous research, projects, papers, and journals that are pertinent to this project. This chapter provides theoretical ideas as well as some project-specific recommendations. In addition, these related duties were thoroughly analysed in order to improve the project's quality and dependability. As a result, this chapter is included to guarantee that a robust implementation strategy is in place for this project.

2.2 Sensors in Patient Monitoring System

2.2.1 Piezoelectric Sensor

A sensor that is well-suited for use in the Covid-19 device as a patient monitor. According to Avnet [1], piezoelectricity is the charge that is generated when mechanical stress is applied across certain materials. Piezoelectric pressure sensors take advantage of this effect by measuring the voltage generated by applied pressure across a piezoelectric element. They have a long service life and can be found in a variety of industrial settings. An electric charge is produced across the faces of a piezoelectric crystal when a force is applied to it. A voltage proportional to the pressure can be used to determine this. When a voltage is applied to a material, the inverse piezoelectric effect occurs, causing the material to change shape. Due to a specific static force, a charge is created across the sensor. However, due to poor insulation, internal sensor resistance, linked electronics, and other factors, this will fade over time. As a result, piezoelectric sensors are rarely used to measure static pressure. The output signal will gradually decrease to zero even in the presence of continuous pressure. They are, however, sensitive to changes in dynamic pressure over a wide range of frequencies and pressures. They can detect even minor changes in pressure in a high-pressure environment due to their dynamic sensitivity.

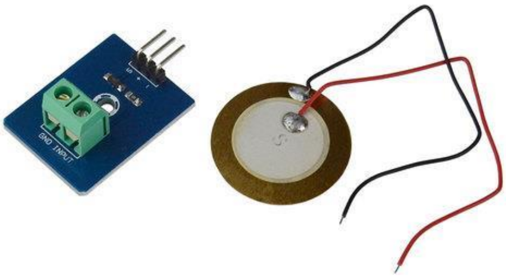

Figure 2.1 : Piezoelectric sensor [2]

2.2.2 Accelerometer Sensor

Human breathing measurement is required or beneficial in a variety of medical and other situations, but the obtrusive nature of current equipment–such as masks, nasal cannulae, and chest bands–has prompted a search for less obtrusive and better-tolerated alternatives, particularly for long-term or home monitoring. Recent interest has piqued in the use of accelerometers to detect the minute rotations of the chest wall that occur during lung expansion and contraction. These rotations of the chest wall are identified using gravity rather than direct measurements of breathing accelerations[3]–[4]. It has been demonstrated in preliminary studies on hospital patients that, with proper processing, this method can produce results that closely match measurements of nasal cannula pressure, and that periods of disruption during patient measurement can be identified and removed. However, this method's research is still in its early stages, and many questions remain unanswered. A major concern is the method's ability to work during speech breathing. These speech differences are concerning from a medical standpoint because they could be mistaken for lung problems. It is hoped that by examining the effects of speech on the breathing signal, it will be possible to distinguish between speech and other respiratory problems that need to be investigated further. Furthermore, respiratory rate is frequently used in clinical settings as a sign of deteriorating patient health. As a result, it's critical that the rate-calculating methods don't produce inaccurate results or unwanted speech alerts.

Accelerometers have never before been used to provide respiratory data while speaking, to our knowledge. Although they have not yet become widely employed in general respiratory monitoring, some research in this field is discussed below. For the first time, the procedure was proven with a single-axis accelerometer, which was tested on dogs and confirmed by embedding a pressure transducer in the trachea to produce an estimated flow rate [5]. Furthermore, the current study discovered that employing a single-axis accelerometer to detect respiration has a significant disadvantage: unless the device is appropriately aligned with the principal axis of rotation, the signal produced by breathing will be faint and likely below the sensor's noise level. Because the principal axis of rotation shifts as the subject's posture or breathing technique varies, device adjustment is required for optimal functioning. The accelerometer is useful for a patient monitoring system.

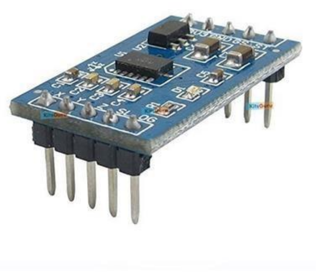

Figure 2.2: Accelerometer sensor

2.2.3 Ultrasonic Sensor

The importance of using a variety of medical equipment to monitor respiratory rate has been emphasized in the literature. These devices can be divided into two categories based on their positioning: those that come into contact with the body and those that do not. Noncontact devices have several advantages, including being more comfortable, preventing electrode skin irritation, lowering patient tension, and reducing surface loading impact, all of which can affect breathing rate [6]. An ultrasonic sensor is one type of non-contact measurement device. Ultrasonic sensors are frequently used to determine the distance between two objects as well as their presence. Using an ultrasonic sensor, this method measures breathing rate based on chest or abdominal surface motions. The ultrasonic sensor works by sending out ultrasonic waves toward the item and capturing the waves that return. The distance will be calculated using the time it takes for the reflected wave to reach the sensor [7]. The device can estimate the respiration rate by monitoring the differences in the body's surface distance with the sensor when inspiration and expiration occur, using the working concept of an ultrasonic sensor.

Ultrasonic sensors are critical for detecting and diagnosing respiratory disorders because they are used to continuously monitor breathing activity. By measuring thorax movement caused by respiratory rhythms, researchers were able to detect abnormal breathing syndromes such as tachypnea, bradypnea, central apnea, and irregular breathing using ultrasonic radar. This study employs an ultrasonic sensor and a PIC18F452 microcontroller to develop a non-contact, non-invasive, low-cost, low-power consumption, portable, and precise system for monitoring normal and abnormal breathing processes in real time [8]. Tidal breathing parameters can be measured in a number of ways, both directly and indirectly [26–28]. Flowmeters that use a direct method to quantify respiratory flow characteristics include thermal and ultrasonic flowmeters. To indirectly monitor respiratory rates, electrocardiography (ECG), photoplethysmography (PPG), pulse oximetry, tracheal breath sounds, impedance pneumography, and other technologies are used. The amount of noise in the environment has a big effect on tracheal breath sound measurements. To determine breathing rates, volume, and flow characteristics, the researchers used piezoelectric respiration transducers, pressure mattresses, abdominal strain gage sensors, microphones, camera-based vision analysis tools, and accelerometers. Peak flow meters are inexpensive, small devices that measure expiratory flow rates but not tidal breathing patterns.

Figure 2.3: Ultrasonic sensor

2.3 Microcontroller in Patient Monitoring System

2.3.1 Arduino Uno R3 Microcontroller

Many historians recommend the Arduino Uno R3 as the best microcontroller for use in monitoring devices. The Arduino Uno R3 can be programmed using the C++ programming language, according to several reports. The pressure sensor was connected to an Arduino Uno microprocessor, which was programmed to detect pressure variations between the infant's breaths, according to one of the findings. The pressure sensor's