SENSOR FOR DETECTION OF AIR POLLUTION

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THIS REPORT IS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF PHYSICS WITH ELECTRONICS WITH HONOURS

PROGRAMME OF PHYSICS WITH ELECTRONICS
FACULTY OF SCIENCE AND NATURAL RESOURCES
UNIVERSITY MALAYSIA SABAH

2014

257287

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BORANG PENGESAHAN STATUS TESIS

JUDUL: SENSOR FOR DETECTION OF AIR POLLUTION

IJAZAH: IJAZAH SARJANA MUDA ~~DENGAN~~ SAINS DENGAN KEPUJIAN FIZIK DENGAN ELEKTRONIK

SAYA: LIEW SHIN TIENG (HURUF BESAR) SESI PENGAJIAN: 2013/2014

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DECLARATION

I hereby confirmed that this dissertation was based on my original work except for the quotations and citations which had been duly acknowledged.

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ACKNOWLEDGEMENT

During this period of time, in order to complete this project there is a few parties that I would like to show appreciation. First of all, I would love to show my appreciation to my respectable supervisor, Dr. Fauziah Sulaiman. Although Dr. Fauziah is always busy with her works, she still manages to spend some time to give me guidance. Her guidance is indeed very detail which makes a great help for me to complete my project.

Next, I would never forget to thanks all the lecturers of Physics and Electronics. They provide me with various knowledge of basic physics concepts that are used to apply in the project. Without the basic knowledge, I believe that this project will not be a success.

Never once forgotten that my coursemates are always by my side to offer a helping hand whenever I need help from them. Therefore, I would also take this opportunity to show my appreciation to them. Not only have they shared information about some of the theory used in this project but they also give opinion on how can I improve my project to be a better one.

Last but not least, I shall show my appreciation towards my family members that gave me support throughout this project. I would love to show appreciation towards my mother that gave me a lot of new ideas and moral support which really gave me a lot of confidence and courage to carry out this project to its final steps. Not to forgot that my father also support me financially during the project. Therefore, I really appreciate what my family members had done for me.

ABSTRAK

Alat Pengesan Pencemaran Udara

Pencemaran udara bukan suatu isu yang baharu bagi manusia. Pencemaran udara boleh berlaku di mana-mana dan pada bila-bila masa sahaja bergantung kepada konsentrasi pencemar udara yang berada di udara. Projek ini dijalankan untuk menghasilkan suatu pengesan bagi mengesan pencemaran udara. Cara ini boleh memberi isyarat awal kepada masyarakat bahawa pencemaran udara melanda. Pada permulaan projek ini dijalankan, sebuah litar dicipta. Kemudian, litar tersebut telah diuji di tiga tempat dan masa yang berlainan yang mempunyai kualiti udara yang berlainan. Apabila konsentrasi pencemar udara yang diuji adalah tinggi, maka alat penggera pada litar berbunyi dalam masa yang singkat. Tempat-tempat yang dipilih adalah di kawasan Universiti Malaysia Sabah (UMS), di kawasan bandar Kota Kinabalu dan di kawasan perindustrian, Kota Kinabalu Industrial Park (KKIP) manakala masa ditetapkan pada jam 7.00 pagi, 12.00 tengah hari dan 5.00 petang. Hasil kajian yang telah didapati apabila litar diuji di ketiga-tiga tempat tersebut menunjukkan di kawasan perindustrian, KKIP, alat penggera pada litar berbunyi pada masa yang paling singkat berbanding dengan di kawasan UMS dan di kawasan bandar Kota Kinabalu. Kajian ini menunjukkan bahawa kawasan perindustrian, KKIP mempunyai konsentrasi pencemar udara yang tinggi.

ABSTRACT

This research in its present form is the result of air pollution which is commonly known. It can happen anytime depending on the concentration of air pollutants that accumulates in the everyday. Therefore, this project is carried out to detect the air pollutants that linger in the atmosphere. It is a way to give people an early signal that the condition of the air that they are breathing in is at an unhealthy level. The concentration of the air pollutants detected by the sensor, if the concentrations of the particles are high, the buzzer trigger in a short time. At the beginning of this project, a circuit to detect the concentration of the air pollution particles is designed and created. It is then tested in three different places and time which has different air quality. The chosen places are University of Malaysia Sabah (UMS), the city area, Kota Kinabalu and industrial area, Kota Kinabalu Industrial Park (KKIP) while the time is 7.00 am, 12.00 pm and 5.00 pm. After the circuit is tested, the result showed that the buzzer rings at the shortest time at KKIP area. It shows that the industrial area, KKIP contains more air pollutants compared to UMS and city area.

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LIST OF SYMBOLS, UNITS, AND ABBREVIATION

API	Air Pollution Index
LED	Light Emitting Diode
CO	Carbon Monoxide
O_2	Oxygen
CO_2	Carbon Dioxide
SO_2	Sulphur Dioxide
O_3	Ozone
NO_X	Oxides of Nitrogen
NO_2	Nitrogen Dioxide
PM2.5	Particulate Matter
PM10	Particular Matter
µg	micro gram
m^3	meter cube
VID	Video Detection System
R	Resistor
V	Voltage
I	Current
SPICE	Simulation Program with Integrated Circuit Emphasis
GUI	Graphical User Interface
3D	Three Dimensions
IC	Integrated Circuit

BJT	Bipolar Junction Transistor
MOSFET	Metal-oxide-semiconductor Field Effect Transistor
MΩ	mega ohm
kΩ	kilo ohm
μF	micro Farad

CHAPTER 1

INTRODUCTION

1.1 Research Background

It was another pollution free day in Malaysia with no area of experiencing unhealthy air quality. One of the most common pollution which usually occurs is the air pollution. Generally, all substances changing the natural composition of air are considered pollutants. When discussing the origins of air pollution a distinction is made between natural and man-made (anthropogenic) sources. High levels of naturally occurring air pollutants, for example, during volcanic eruptions, during sand storms, during forest fires, during processes related to air-chemistry in thunderstorms and also from plant pollen.

Anthropogenic air pollutants will be primarily dealt in work. One differentiates between particulates and aerosols (fine dusts and extremely fine droplets distributed in the air) on one hand and gases on the other. Visible air pollutants include dusts or droplets like smoke, soot, oil mists; only a few gases, however, are visible. Anthropogenic air pollution had its beginnings when man started to use fire. Smoke, carbon monoxide (CO), carbon dioxide (CO_2) and organic gases are pollutants resulting from this (Baumbach, 1996).

In nomadic and rural cultures pollution of indoor air was high, whereas in the densely populated cities of advanced civilisations the outdoor atmosphere also deteriorated. In pre-industrial times the most significant sources of air pollution were foundries, potteries as a trade with high energy consumption and the smoking of fish and meat. The smelting of ores released acid gas from roasting and dusts containing large amount of heavy metals. The damage done to fields, meadows and fruit in the surroundings of the foundries of this era which were almost exclusively located in the highlands led to neighbourhood conflicts between foundry people, landowners and farmers, especially in narrow valleys.

With regard to air quality, the invention of the steam engine by James Watt (Baumbach, 1996) in 1769 ushered in a new era. Within a few decades energy consumption soared. Smoke and ash became the main problem when coal was burned for the firing of boilers of stationary steam engines and locomotives as well as in home stoves. At the same time, production rates in almost all branches of trade increased and with them their emissions. The variety of air pollutants increased rapidly, particularly due to the growing chemical industry.

England and France, the vanguards of industrialization, were the first states whose governments and administrative authorities were forced to deal with complaints about increasing environmental damage. Not only was France the first country to require approval for steam engines in 1823, it was also the first to introduce regular checks for them by state-employed test engineers. In Germany, boiler operators took on this task from 1866 in voluntary cooperation with the technical inspection authorities (Baumbach, 1996).

While the majority of the population of the 19th century considered "smoking chimneys" the hallmark of technical progress and not least their livelihood, agriculture and forestry had to cope with the effects of air pollution. In this context, air quality analyses for sulphur dioxide (SO_2) in air and for sulphate in rain water

were developed, and critical SO_2 concentration threshold values were determined for plants and human beings.

The most important anthropogenic source groups of air pollution are industrial furnaces and industrial processes, traffic, small-scale business and domestic furnaces as well as special sources such as animal's confinement systems, spray cans etc. A major proportion of the pollutants caused in these different areas have its origin in combustion processes, either in industrial and domestic furnaces or in traffic from combustion engines and aircraft engines. When burning fossil fuels for generating heat or power, a wide variety of air polluting substances can be created. Those substances include CO, soot, hydrocarbon, sulphur oxides (SO_x), and nitrogen oxides (NO_x). Formation of smog and ozone (O_3) also contribute to formation of air pollution (Perkins, 1974). It is feared today, that the protective ozone layer in the stratosphere is being depleted by man-made air pollutants.

The extent of the negative effects of air pollution can vary greatly. They range from an imperceptible basic load to irritation, sickness and death. The disorders caused do not occur immediately on exposure but after prolonged exposure or accumulation. Common effect on humans' health is the possibilities and difficulties in breathing. For those who suffer from asthma or lung problem suffer a greater impact when there is air pollution. Smoking is famous but also contributes to air pollution with the accumulation of cigarette smoke into the air. Inhaling too much tobacco smoke can highly damage the lungs. Air pollution may affect humans' health greatly but it also brings effect to the surrounding. Air pollution can helps to increase the temperature of the surrounding. Increase in temperature may lead to global warming and greenhouse effect, in which high energy ultraviolet light warms the surface of the Earth, however due to the thinning of stratospheric ozone layer, it allows more ultraviolet light to reach the Earth's surface. Higher occurrence of individual atmospheric pollutants in the vicinity of industrial such as SO_2 containing heavy metals and alkalines are able to damage plants (Baumbach, 1996).

1.2 Objectives of Study

The objectives of this study are:

- To study and determine the particles that contains in air pollution.
- To design and create a portable sensor that is easy to bring along to any place and it will sound an alarm with the Light Emitting Diode (LED) lights up when the concentrations of the pollutants are high enough to raise the reading of the API to reach hazardous state.
- To be able to give an early signals as well as early precaution to society the presence of air pollution.

1.3 Scope of Study

This study focused to the concentrations of the pollutants is high enough to raise the reading of the Air Pollution Index (API) to reach hazardous state. As the API reading reaches 101, the status of the atmosphere consider unhealthy. This condition will then cause the alarm to activate thus, producing an alarm as precaution to the people around. The device is not heavy and it is suitable to be carried around by everyone regardless the age and time. This device also focused to be used in the city area and not rural area or countryside. However, this device although is not dangerous, it is better if it is not handle by children.

1.4 Hypothesis

In this research, it is assumed that higher concentration of smoke which is the main source of air pollution will trigger the alarm of the sensor and the LED will lights up at a shorter time. This way can help people to be alarmed and alert that the air pollution is occurring or considers the atmosphere is at hazardous state.

1.5 Definitions

Some of the scientific definition describing the terms used for air pollutants in the air.

1.5.1 Carbon monoxide

Carbon monoxide, also known as CO, is a colourless, odourless poisonous gas and is a common yet preventable cause of death from poisoning worldwide. Photo 1.1 shows the structure of carbon monoxide.

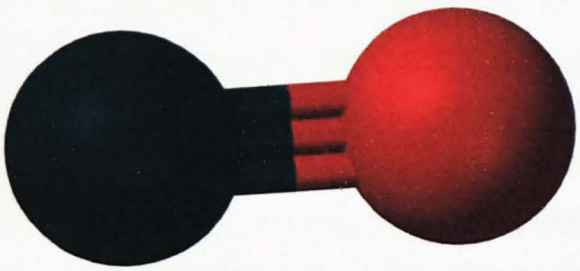

Photo 1.1 Structure of carbon monoxide (Morris, 2013)

CO has no smell, taste and odourless. This is why CO also known as the "Silent Killer" when it poisons people. The common environmental source of CO is the incomplete combustion of organic fossil fuels such as oil, gas or coal. However, the largest fraction by far is caused by gasoline-fueled motor vehicles. Most emissions occur in urban areas and this often means high concentrations along downtown streets where concentrations of 10-15ppm for 8-hour periods are common during the driving day; even higher concentrations have been measured in major cities (Perkins, 1974).

During the combustion process, oxygen, O_2 is added. The carbon in the fossil fuel will combine with the oxygen in the air to produce carbon dioxide; CO_2 which is the air that human's exhale. However, if there is a lack of air for the combustion process, CO can be produced and it is then released into the atmosphere. When CO is inhaled into the body, it will combine with the blood, preventing it from absorbing O_2. Symptoms of illness and death can occur if a person is exposed to CO over a period of time.

1.5.2 Haemoglobin

Haemoglobin is an oxygen carrier that is found in red blood cells. A drop of blood contains millions of red blood cells or erythrocytes. These cells take the shape like flattened discs with greater surface area that allows exchange of oxygen and carbon dioxide in the lungs and with body cells easily. Red blood cells carry oxygen to other parts of the body efficiently due to a special protein inside them called the haemoglobin. Haemoglobin contains a haem prosthetic group that has an iron atom at its centre. When the iron is bound to oxygen, the haem group is red in colour (oxyhaemoglobin), and when it lacks oxygen (deoxygenated form) it is blue-red. When blood passes through the lungs, the haemoglobin picks up oxygen because of the increased oxygen pressure in the capillaries of the lungs, and can then release this oxygen to body cells where the oxygen pressure in the tissues is lower. Besides that, the red blood cells also transport the waste product, carbon dioxide, some of which is carried by the haemoglobin (at a different site from where it carries the oxygen), while the rest is dissolved in the plasma. The high carbon dioxide level in the tissues lowers the pH, and the binding of haemoglobin to carbon dioxide causes a conformational change that facilitates the release of oxygen. The carbon dioxide is then released once the red blood cells reach the lungs (McDowall, 2005).

Haemoglobin is composed of four polypeptide chains, which in adults consist of two alpha (a) globin chains and two beta (b) globin chains. Each polypeptide has a haem prosthetic group attached, where each haem can bind one oxygen molecule - so there are four haem groups per haemoglobin molecule that together bind four oxygen molecules (McDowall, 2005).

1.5.3 Smog

Smog is a type of air pollution. It usually forms in industrial areas or high population, which release large amounts of air pollution, such as smoke or gases which leads to haze. Other than industrial areas, emissions from motor vehicles, paints, solvents and gasoline fumes are also some factors that contribute to formation of smog when they are release into the air. When the pollutants react, with the help of the sunlight, they form ground-level-ozone, the main component of smog (Allaby, 2003).

There are two types of smog: summer smog and winter smog. During the cooler months (April to September), warm air higher in the atmosphere traps pollutants in the layer of cold air closer to the ground. These temperature inversions can last for several days and cause 'scummy' brown hazed horizons until dispersed by wind or rain. On the other hand, during the warmer months (October to March), photochemical smog also known as summer smog is caused by the action of sunlight on a mixture of hydrocarbons and oxides of nitrogen. In this smog, it contains secondary pollutants such as ozone, aldehydes and fine particles.

1.5.4 Sulphur Dioxide

Sulphur dioxide, also known as SO_2 is one of the particles that are released when a large amount of smoke is released into the atmosphere. SO_2 is a colourless gas which smells like burnt matches. Photo 1.2 shows the structure of sulphur dioxide.

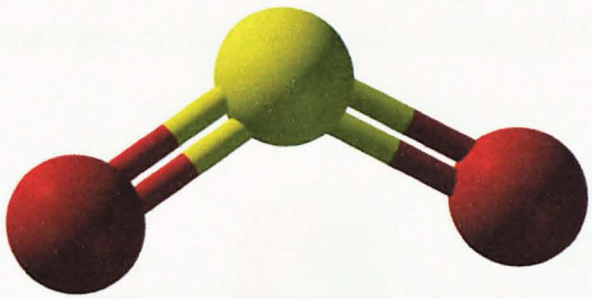

Photo 1.2 Structure of sulphur dioxide (Gibb, 2011)

With the presence of water vapour, it can be transformed to sulphur trioxide and can be oxidized to form aerosols. SO_2 is a precursor to sulphates, which are one of the main components of respirable particles in the atmosphere. Some of the sources that cause the formation of SO_2 are from transportation, cement and concrete, downstream petroleum industry and other industry processes (Zaini, 2000).

With the presence of SO_2 in the atmosphere, health problem increases when there is too much exposure to the gas. Health effects include breathing problems, respiratory illness, changes in the lung's defences, and worsening respiratory and cardiovascular disease. Presence of SO_2 makes the situation more difficult for people with asthma or chronic lung or heart disease. Other than health problem, SO_2 also damages trees and crops. Along with the presence of nitrogen oxides, SO_2 are the main components of acid rain. SO_2 also causes the formation of microscopic acid

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