SUPERVISOR APPROVAL

'I admit that I have read this literature work through my observation which has fulfilled the scope and quality in order to be qualified for the conferment of Bachelor Degree in Electronic Engineering (Electronic Industry).'

Signature : .....

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Date : 12th May 2006

DESIGN AND IMPLEMENTATION OF CARBON MONOXIDE (CO) AND NITROGEN DIOXIDE (NO_2) DETECTOR BY USING PERIPHERAL INTEGRATED CONTROLLER (PIC)

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DECLARATION

"I admit that this is done by my self except the discussion and extracts taken from other sources that I explained each in detail."

Signature : .....

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Date : 12th May 2006

DEDICATION

To my parents, family members and friends;
My all times beloved.

ACKNOWLEDGEMENTS

Alhamdulillah, I finally able to complete the final year project and the thesis as well within the allocated time. First of all, I would like to take this opportunity to express my appreciation to some organizations and individuals who have kindly contributed to the successfully completion of my final year project in KUTKM. With the cooperations and contributions from all parties, the objectives of the project; soft-skills, knowledge and experiences were gained accordingly. To begin with, I would like to convey my acknowledgement to KUTKM PSM organization members especially my project supervisor, Pn Fauziyah Salehuddin for her cooperation and involvement from the begining untill the end of my project development. Her effort to ensure the successfull and comfortability of students under her responsibility was simply undoubtful. Thanks for the invaluable advices given before, while and after completion of the project. Furthermore, I would like to extend my sincere acknowledgement to my parents and family members who have been very supportive throughout the project. Their understanding and support in term of moral and financial were entirely significance towards the project completion. Last but not list, my appreciation goes to my fellow colleagues in KUTKM, especially for those who came from FKEKK. Their willingness to help, opinions and suggetions on some matters, advices and technical knowledge are simply precious while doing upon completion of my final year project.

ABSTRACT

Toxic gasses usually referred to and synonym with these particular characteristics, poisonous, odorless and invisible gasses. For this project, the toxic gasses are specified to Carbon Monoxide (CO) and Nitrogen Dioxide ($N0_2$). Both gasses are likely being produced from the same sources. Generally, the fuel burning devices such as vehicles and some fuel based equipments, like certain machineries that existed in industry. Due to the high exposure of those mentioned gasses in certain concentration and period of times, humans health can be affected seriously which in the worst situation will lead to fatal accident. Since these toxic gasses are invisible and hardly detected through normal human senses, this project is developed which purposely carried in order to design a device that can detect, measure and notify the user on the existence of the toxic gasses. As the enhancement of the previous project, a single device that is used to detect more than one toxic gas is expected to be design by using the PIC microcontroller. Well supported with the toxic gasses sensor, buzzer and LCD display, this project is targeted to be an alternative tool to detect, measure and warn on the level of seriousness of those mentioned toxic gasses that may surround the user before any further action taken for the sake of safety.

ABSTRAK

Gas bertoksik lazimnya dikaitkan dengan beberapa kriteria iaitu beracun, tidak berbau dan tidak boleh dilihat. Atas kriteria tersebut, projek ini dibangunkan dengan memberi penekanan dan fokus kepada dua jenis gas toksid iaitu Karbon Monoksida (CO) dan Nitrogen Dioksida (NO_2). Kebiasaannya, kedua-dua jenis gas toksid tersebut dikeluarkan atau diperolehi dari sumber yang hampir sama iaitu objek yang melibatkan pembakaran minyak seperti kenderaan dan jentera, serta asap dari pembakaran seperti dapur arang dan asap rokok. Pendedahan yang berterusan untuk suatu jangka masa atau pada suatu tahap kepekatan yang tinggi terhadap gas-gas toksid ini boleh membawa kemudaratan dan menjejaskan kesihatan manusia. Dalam keadaan yang serius, kematian atau kemalangan jiwa berpotensi untuk terjadi jika tiada langkah-langkah pemulihan diambil dengan kadar segera. Disebabkan kritirea gas tersebut yang tidak berbau dan sukar untuk dilihat, projek ini dibangunkan dengan tujuan untuk mengesan, mengukur dan memberi amaran awal kepada pengguna berkenaan dengan keadaan persekitaran mereka. Melalui penggunaan mikropengawal (PIC Microcontroller) yang disokong oleh pengesan dan 'buzzer', kepekatan gas dalam unit PPM (Part per million) akan dipaparkan pada LCD. Mikropengawal pula akan mengaktifkan fungsi 'buzzer' sebagai amaran jika kepekatan gas melebihi suatu tahap yang ditetapkan. Kejayaan projek ini dijangka dapat menjadi bahan alternatif untuk mengawasi tahap ketoksidan di sesuatu persekitaran untuk tujuan keselamatan dan kesihatan.

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LIST OF ABBREVIATIONS

CO	-	Carbon Monoxide
NO_2	-	Nitrogen Dioxide
PIC	-	Peripheral Integrated Controller
PCB	-	Printed Circuit Board
LCD	-	Liquid Crystal Display
LED	-	Light Emitting Diode
ADC	-	Analog To Digital Converter
PWM	-	Pulse Width Modulation
UV	-	Ultra-Violet
PPM	-	Part Per Million

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CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

Nowadays, safety has become one of the important things and major concern to the public. The exposure towards the hazardous environment intentionally or unintentionally could raise the possibilty of being involved in accident. As a solution, a lot of safety products and devices have been designed and developed in order to prevent and overcome the scenario.

1.2 PROJECT OVERVIEW

Nowadays, we are easily exposed ourselves to risky surrounding that can harms and jeopardizes our life. Combustion gasses produced from fuel burning devices such as gas-fired furnace and vehicles contain some invisible toxic gasses that cannot be detected through human senses. The symptoms of carbon monoxide (CO) poisoning mainly dizziness, headache, cough and vomiting are well recognized and it

is usually detected early. Nitrogen dioxide, on the other hand, is a known airway irritant, but the symptoms may be delayed for a period of several hours up to days, during which time cough, hemoptysis, dyspnea and chest pain can occur. For the worst situation, fatal accident might occur due to the both toxic gasses produced.

With regards to the toxic gasses poisoning, problem with air pollution in indoor ice arenas have previously been documented but have not been widely recognized. The main toxic agent has been carbon monoxide (CO), but in recent years, investigators have also described toxic effects resulting from nitrogen dioxide exposure. The problems are usually caused by malfunctioning ice-resurfacing machines in combination with poor ventilation. The hazard of exposure to poisonous gasses in indoor ice arenas is a potential public health problem in many countries in which ice hockey and other ice-skating activities are popular. Brauer and Spengler, two free researchers also noted that in indoor ice arenas, extreme exposure are presence which unlikely to exist in other indoor, ambient, or occupational settings.

From toxic gasses poisoning case reported, several adolescents who had played ice hockey in an indoor ice arena in Stockholm possessed an acute respiratory illness. During the day of the incident and the following 2 days, 20 players sought medical assistance, and 2 were admitted to intensive-care units because they had impaired lung function. Their symptoms were cough, chest pain, and shortness of breath. High levels of combustion gases were suspected to be the main causes. Lack of attention and concern among the hockey players towards the environment quality are believed contribute, lead and make the problem worse [6].

In this scenario, a device that can sense those toxic gasses is expected to be design to overcome the problem. Towards the end of the project, a single device that will be used to detect more than one hazardous gas such as Carbon Monoxide (CO) & Nitrogen Dioxide (NO_2) is expected to be designed by using PIC microcontroller. The goal of this project is to find an alternative path to detect, warn and measure the

level of seriousness of those mentioned gasses at certain specific location before any further action taken for the sake of safety.

1.3 OBJECTIVES

The objectives of the project consist of:

a) To design a device that can detect and analyze the existence of Carbon Monoxide (CO) and Nitrogen Dioxide (NO_2).

b) To study the characteristic and details of toxic gasses.

c) To study the functionality of the PIC so that it can be applied in electronic control system and safety product.

d) To study the communication between software and hardware to perform the project.

e) To determine type of sensors that available in market, its suitability and compatibility with the project design.

1.4 SCOPE OF WORKS

In the beginning of the project development, several factors were considered to determine the limitation or final outcome of the product. For this project, it is aim to sense and measure two types of toxic gasses such as Carbon Monoxide (CO) and Nitrogen Dioxide. From the research, there are two options of sensor that available and suit the project requirement. The first one is by using a multi purpose sensor, and the other one is by using two different sensors separately. However, for this project,

in order to avoid problem in detecting which gas is being sensed, two types of different gas sensors will be used instead of a multipurpose gas sensor. The first sensor is mean for the Carbon Monoxide, while the other one for the Nitrogen Dioxide detection. During the functional implementation process, if the product being place in one particular area, it will only sense, measure and display the targeted gasses. Toxic gasses other than CO and NO_2 will be ignored.

Since this device is aimed to be use domestically, it should not being exposed or operated in extreme condition. For example, through the research on the existing product, this device should be able to monitor and detect toxic gas from 0 to 9999 ppm. However, as stated earlier, this device is design on safety purpose. It is mean for small area monitoring only. That means, there is no used to expose it till that level of condition since 800 ppm for CO is already an average life limit for human. So, the range of concentration level of this device will be less than 1000 ppm. The ideal operating environment for this device is small working area such as kitchen and garage where combustion gasses are produced. As a small area-monitoring device, it should not be used in a large targeted area to avoid inaccurate measurement where for this situation; more sensors are needed to cover the working area.

1.5 THESIS OUTLINE

This thesis represent by five chapters. Chapter I will focus on brief introduction of the project carried. The important overview or description including the problem statement, project objectives and project scopes are well emphasized in this part.

Chapter II will be based on the literature review of the project. It is mainly focused on the target toxic gasses characteristic such as their visibility and toxicity. It also defined the details including the source and effect of the toxic gasses towards the human health.

Chapter III will explain on the concepts, theories and principles used in order to complete the project. This part consists of the methodology and also the information on research and experiment carried during the project development.

Chapter IV mainly focused on the result and analysis done using the device. All testing and verification result are attached with the aid of figure, table and statistic related to the project. Chapter V is a complimentary of previous four chapters. It describes on the overall project, discussion and suggestion for the project. All matters arise including the problems and unachieved objectives will be described clearly in this part.

CHAPTER II

LITERATURE REVIEW AND CONCEPTS

2.1 GENERAL DESCRIPTION OF TOXIC GASSES

Carbon Monoxide and Nitrogen Dioxide are two types of toxic gasses with poisonous, invisible and odorless characteristics. In order to design a device to monitor the level of the toxic seriousness, the details of the gasses it need to be researched and determined for better understanding of the sensing target. It is essential and important process during the design and implementation process.

Carbon Monoxide (CO) is a colorless, odorless, and tasteless gas. This invisible, poisonous gas is produced from burning fuels such as natural gas, gasoline, fuel oil, or wood (in indoor heating systems, car engines, cooking appliances, or fires). Carbon Monoxide poisoning develops when you inhale enough carbon monoxide for it to begin to replace the oxygen that is carried in the blood. This is because Carbon Monoxide binds to red blood cells about 250 times more strongly than oxygen does [2]. As the oxygen in the blood is replaced by carbon monoxide, the body's organs and tissues, which depend on oxygen, cannot work properly.

The Consumer Products Safety Commission (CPSC) reports that approximately 200 people per year are killed by accidental CO poisoning with an additional 5000 people injured. These deaths and injuries are typically caused by improperly used or malfunctioning equipment aggravated by improvements in building construction, which limit the amount of fresh air flowing in to homes and other structures.

One of the most prevalent oxides of nitrogen is nitrogen dioxide (NO_2). It is kind of toxic gas with highly reactive oxidant and corrosive. The primary indoor sources are combustion processes such as invented combustion appliances; gas stoves, vented appliances with defective installations, welding, and tobacco smoke. NO_2 acts mainly as an irritant affecting the mucosa of the eyes, nose, throat and respiratory tract.

Extremely high-dose exposure (as in a building fire) to NO_2 may result in pulmonary edema and diffuse lung injury. Continued exposure to high NO_2 levels can contribute to the development of acute or chronic bronchitis. Low-level NO_2 exposure may cause increased bronchial reactivity in some asthmatics, decreased lung function in patients with chronic obstructive pulmonary disease and increased risk of respiratory infections, especially in young children.

As a conclusion, while regular maintenance and inspection of gas burning equipment at home can minimize the potential for exposure to toxic gasses, the possibility for some type of sudden failure resulting in a potentially life threatening build up of gas always exists.

2.2 CARBON MONOXIDE (CO)

Carbon Monoxide with a chemical formula CO, is a colorless, odorless, tasteless, flammable and highly toxic gas. It is a major product of the incomplete combustion of carbon and carbon-containing compounds [2]. It is less dense than air under ordinary conditions. However it accumulates on the ground, meaning that if poisoning caused loss of consciousness, the amount of carbon monoxide inhaled increases and so fatality is radically increased. It is very slightly soluble in water and burns in air with a characteristic blue flame, producing carbon dioxide, it is also a component used in producing gas and water gas which is widely used artificial fuels. It is a reducing agent, removing oxygen from many compounds and is used in the reduction of metals, such as iron, from their ores.

At high pressures and elevated temperatures it reacts with hydrogen in the presence of a catalyst to form methanol. Carbon Monoxide is formed by combustion of carbon in oxygen at high temperatures when there is an excess of carbon. It is also formed with byproduct oxygen by decomposition of carbon dioxide at very high temperatures (above 2,000 °C). It is present in the exhaust of internal-combustion engines, often the exhaust of automobiles, and is generated in coal stoves, furnaces, and gas appliances that do not get enough air. This may be due to insufficient ventilation or other reasons [2].

2.2.1 CO Sources

Carbon Monoxide is a colorless, odorless, tasteless and toxic gas produced as a by-product of combustion. Any fuel burning appliance, vehicle, tool or other device has the potential to produce dangerous levels of carbon monoxide gas.

Examples of devices that commonly produced carbon monoxide include:

i) Fuel fired furnaces (non-electric)
ii) Gas water heaters
iii) Fireplaces and woodstoves
iv) Gas stoves
v) Gas dryers
vi) Charcoal grills
vii) Lawnmowers and other yard equipment
viii) Power Generators
ix) Automobiles

2.2.2 CO Health Effects

Carbon Monoxide inhibits the blood's ability to carry oxygen to body tissues including vital organs such as the heart and brain. When CO is inhaled, it combines with the oxygen carrying hemoglobin of the blood to form carboxyhemoglobin. Once combined with the hemoglobin, that hemoglobin is no longer available for transporting oxygen [2]. How quickly the carboxyhemoglobin builds up is a factor of the concentration of the gas being inhaled (measured in parts per million or PPM) and the duration of the exposure. Compounding the effects of the exposure is the long half-life of carboxyhemoglobin in blood. Half-life is a measure of how quickly levels return to normal. The half-life of carboxyhemoglobin is approximately 5 hours. This means that for a given exposure level, it will take about 5 hours for the level of carboxyhemoglobin in the blood to drop to half its current level after the exposure is terminated. The following table 2.1 describes the symptoms associated with a given concentration of COHb:

Table 2.1: Symptoms and consequences in term of COHb percentage in blood

% COHb	Symptoms and Medical Consequences
10	No symptoms. Heavy smokers can have as much as 9% COHb.
15	Mild headache
25	Nausea and serious headache. Fairly quick recovery after treatment with oxygen and/or fresh air.
30	Intensify potential of long term effects especially in the case of infants, children, the elderly, victims of heart disease and pregnant women.
45	Unconsciousness
> 50	Death

The following table 2.2 describes the toxicity level in concentration level (PPM) and duration of exposure.

Table 2.2: Symptoms in term of gas concentration and exposure period

PPM	Time	Symptoms
35 PPM	8 hours	Maximum exposure allowed by OSHA in the workplace over an eight-hour period.
200 PPM	2-3 hours	Mild headache, fatigue, nausea and dizziness.
400 PPM	1-2 hours	Serious headache- other symptoms intensify. Life threatening after 3 hours.
800 PPM	45 minutes	Dizziness, nausea and convulsions. Unconscious within 2 hours. Death within 2-3 hours.
1600 PPM	20 minutes	Headache, dizziness and nausea. Death within 1 hour.
3200 PPM	5-10 minutes	Headache, dizziness and nausea. Death within 1 hour.
6400 PPM	1-2 minutes	Headache, dizziness and nausea. Death within 25-30 minutes.
12,800 PPM	1-3 minutes	Death.