UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF INDOOR AIR QUALITY (IAQ) DISPLAY UNIT USING ARDUINO

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electrical Engineering Technology (Telecommunication) with Honours.

by

AHAMMAD SADIQ BIN YUSOFF
B071410585
930709-08-5411

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Date	:	22 December 2017

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electronic Engineering Technology (Telecommunication) with Honours. The member of the supervisory is as follow:

.....

(Project Supervisor: Mohd Khanapiah Bin Nor)

ABSTRAK

Projek ini membentangkan proses reka bentuk dan pembangunan untuk menghasilkan platform berbagai sensor yang mudah dan kos efektif, unit paparan kualiti udara dalaman (IAQ) menggunakan Arduino. Pada masa kini, perkembangan pesat industri ini terus menggalakkan kemajuan dan kesinambungan teknologi dan juga peningkatan kadar hidup. Malangnya, secara tidak langsung ini membawa kepada pencemaran alam sekitar dan ia mendapat perhatian serius dari semua orang dan sukar untuk memastikan persekitaran yang selamat untuk penjagaan kesihatan. Memandangkan keadaan udara semakin tercemar, unit IAQ atau unit pemantauan dalaman berkembang pesat setiap hari sesuai dengan permintaan pengguna yang semakin meningkat untuk prestasi reka bentuk sistem yang tepat dan lebih baik. Walau bagaimanapun, reka bentuk sistem elektronik untuk pemantauan alam sekitar tidak selalunya mudah. Oleh itu, reka bentuk yang lebih efektif daripada sensor yang tepat dan cekap bersama-sama dengan kos yang sesuai adalah lebih baik. Prosedur awal melibatkan pengembangan kedua-dua perisian dan peralatan. Pada asasnya, pembangunan perisian adalah untuk menghasilkan paparan yang mesra pengguna dan juga untuk menghasilkan kod untuk unit pemprosesan. Selain itu, pembangunan peralatan adalah lebih banyak untuk memasang semua komponen dan sensor. Kemudian, ia diikuti dengan gabungan kedua-dua bahagian untuk mendapatkan alat berfungsi sepenuhnya. Kemudian pelajar menjalankan ujian dan analisis alat yang telah siap untuk mengesahkan prestasi. Beberapa program perisian komersial juga telah digunakan melalui Visual Studio Express 2012 untuk reka bentuk paparan, IDE untuk menghasilkan kod untuk Arduino UNO, dan Proteus ISIS untuk reka bentuk dan simulasi litar. Unit Paparan IAQ mempunyai keupayaan untuk mengukur dan memaparkan empat parameter kualiti udara iaitu kelembapan, suhu, karbon monoksida dan asap dalam masa nyata. Oleh itu, alat ini akan sangat berguna dan serasi dalam memaparkan kualiti udara semasa dalam persekitaran tertutup.

ABSTRACT

This project presents the process in design and development to produce a simple and cost effective multi-sensor platform, indoor air quality (IAQ) display unit using Arduino. Nowadays, the current rapid development of the industry directly promotes the progress and continuity of technology and also the improvement of living conditions. But unfortunately, this indirectly leads to the environmental pollution and it's getting serious attention from all people and it is difficult to ensure safe environment for health maintenances. As the condition of air are getting polluted, an indoor air quality (IAQ) display unit or monitoring unit are rapidly develop day by day corresponding to the increasing users demand for an accurate and improved system design performance. However, design of electronic systems for environmental monitoring is not often straightforward. Thus, a simpler design of an accurate and efficient sensors along with suitable cost are preferable in designing an Indoor Air Quality (IAQ) display unit. In this work, the initial procedure involves in the development of both software and hardware part. Basically, the software development is to generate a user-friendly interface using Visual Studio and also to generate the coding for the processing unit. On the other side, the hardware development is more to assembling all the components and sensors. Then, it is followed by the integration of both part to obtain a fully-functional device. It is then required by the student to conduct testing and analysis of the completed device to validate the performance. Several commercial software programs have also been used through-out the project which is the Visual Studio Express 2012 for design of the interface, Integrated Development Environment (IDE) for generating coding for Arduino UNO, and Proteus ISIS for circuit design and simulation. The Indoor Air Quality (IAQ) Display Unit has the ability to measure and display the four air quality parameters which is the humidity, temperature, carbon monoxide and smoke in real time. Thus, the device would be very useful and compatible in providing the current air quality in indoor environment.

DEDICATIONS

To

My father Yusoff Bin Veerasa for his love, encouragement and patience.

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&

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CHAPTER I
INTRODUCTION

1.0 Introduction

In this chapter, the brief insight of developing an Indoor Air Quality (IAQ) Display Unit using Arduino has been discussed. This include as what problem arises that triggers the motivation for the project development based on general specifications, scope of work and also expected outcome at the end of this project.

1.1 Project Background

The current rapid development of the industry directly promotes the progress and continuity of technology and also the improvement of living conditions. But unfortunately, this indirectly leads to the environmental pollution and it's getting serious attention from all people and it is difficult to ensure safe environment for health maintenance. As the condition of air are getting polluted either it is outdoor or indoor, an indoor air quality (IAQ) display unit or monitoring unit are rapidly develop day by day corresponding to the increasing users demand for an accurate and improved system design performance. Although there are well known and widely used design methods for measurement of the air quality parameter as in **Figure 1.1**, design of electronic systems for environmental monitoring is not often

straightforward. Thus, a simpler system design, with an accurate and efficient sensors along with suitable cost are preferable in designing an Indoor Air Quality (IAQ) display unit. It is important to choose the appropriate sensor based on the design requirement, the detecting range along with the cost consideration. In addition, both Visual Studio and Arduino will be used through-out this project to assist with the simulation and developing process of the indoor air quality display unit. Then, the complete design prototype will be analyze, validate and test to ensure that it meets the requirement of specification in measuring the air quality performance.

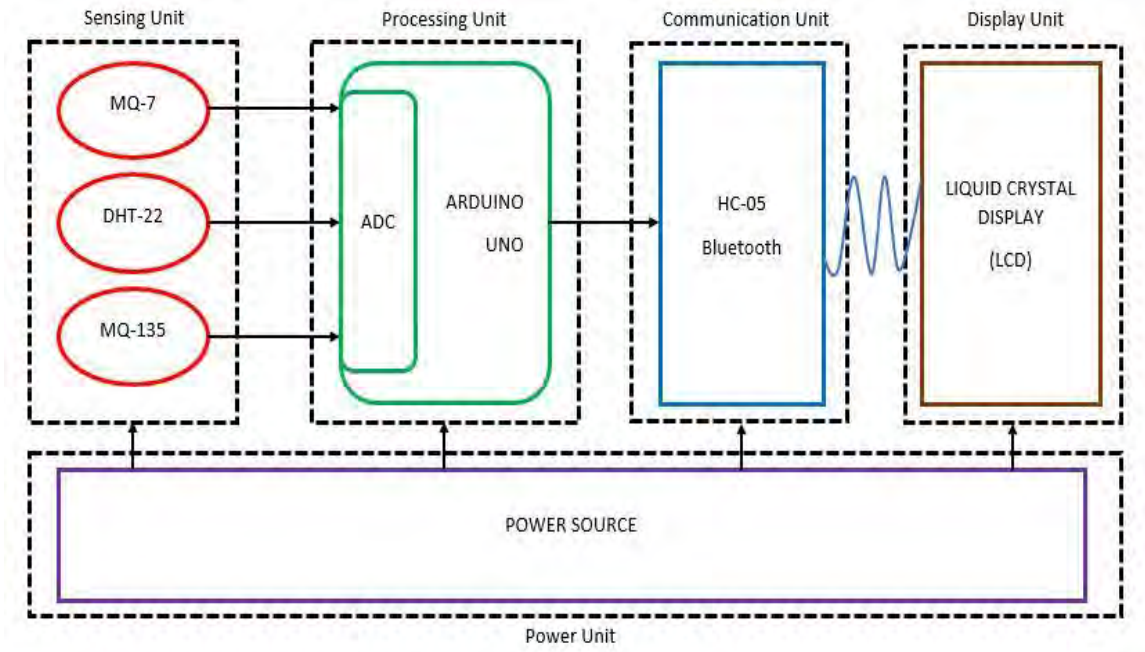

Figure 1.1: Block Diagram Representation of System Model

1.2 Problem Statement

Nowadays, due to the world of growing population and advancing industry, people tend to pay more attention in improving their living condition and physical health. Furthermore, these rapid development in industry especially in the urban civilization leads to the environmental pollution, where people are exposed to various

type of gases such as Carbon Monoxide (CO), Ammonia (NH_3) and Nitrogen Oxide (NOx) that can be hazardous, poisonous and further result to health problems and then affect the human productivity.

The main concern of this project is to study and develop an Indoor Air Quality (IAQ) display unit by using Arduino. Primary steps is to study and develop both software (Visual Studio & IDE) and hardware (Sensors, Bluetooth & Arduino) part. Then followed by the integration of both part and testing the functionality of the complete design. Since the air quality and the performance of the design can be determine by analyzing the selected air quality parameters such as CO, humidity and temperature along with hazardous gas, thus it is great important to perform the validation and testing process. This steps will include exposing all three sensor device to selected gases and allow the device to monitor and analyze the gases and compare it with the acceptable range, and then finally display the level of each gases at the LCD via Bluetooth and state to the user whether the indoor environment is safe or polluted.

1.3 Objectives

The two (2) main objectives of the project are:

1. To study and develop a simple and cost effective multi-sensor platform indoor air quality (IAQ) display unit through software and hardware design by using Visual Studio and Arduino.
2. To successfully propose and produce an efficient and effective indoor air quality (IAQ) display unit that assist users in monitoring current air quality.

1.4 Scope of Work

This project is mainly to study and produce a prototype of an indoor air quality (IAQ) display unit with the core developed system can be describe as the system integration of Visual Studio, Integrated Development Environment (IDE) and Arduino-based circuit board attached along with several sensors devices and Bluetooth. In this research, included sensors will provide information regarding the concentration of carbon monoxide, air temperature and relative humidity as well the presence of hazardous gas in the indoor environment at the LCD. The general specifications of the IAQ display unit are describe as the following:

TABLE 1.1 Specifications of IAQ Display Unit Using Arduino

Power Unit	Consist of one power source which supply voltage to all units connected to it. (sensing, processing and display unit)
Sensing Unit	Consist of three (3) sensors and ADC • MQ-7 (CO) • DHT-22 (Relative humidity and temperature) • MQ-135 (Hazard gas – NH_3, NO_X, CO_2, smoke)
Processing Unit	Consist of Arduino Microcontroller as the core component of the propose design.
Display Unit	Consist of both Visual Studio Software and a Liquid Crystal Display (LCD) which is generally a reliable electronic module to display required information.
Communication Unit	Bluetooth

1.5 Methodology

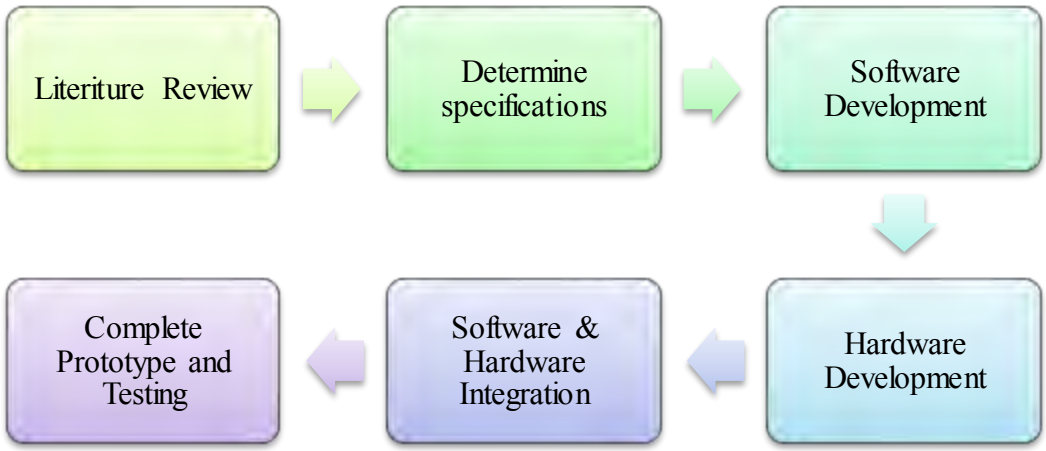

Figure 1.2: General project methodology flowchart

Generally, this project will involve six (6) general phase. The first phase which is the literature review is very important during the entire project since it focuses on finding the related information and theories regarding the indoor air quality monitoring as it will provide firm knowledge and understanding in developing the IAQ display unit. The second phase involves the determination of the system specifications such as the type of gases to be detected and measured by the sensors, It is important to determine the specifications as it can provide guidelines and limitations on a certain limit that the overall system need to achieve in order to obtain a successful prototype development. Next is the third phase which is mainly involving the software development. This is done by generating the required coding for each sensors. Using the information previously, the fourth phase will involve the hardware development. The software and hardware integration will be conducted in the fifth phase. The sixth phase is crucial because the system will require further testing in order to validate that the system obtain the desired response and specifications. The last phase will come out with the final design prototype of IAQ display unit using Arduino that detect and display levels of CO, relative humidity and temperature also with hazardous gases at LCD Display via Bluetooth.

1.6 Report Structure

The report mainly consists of five (5) chapters. Chapter I is the Introduction, while Chapter II and Chapter III are the Literature Review and Design Methodology respectively. In addition, the last two chapter is the most important part in the thesis. The Software with Hardware Development and Discussion covered in Chapter IV. Conclusion and Future Work in Chapter V respectively. The motivation for the project, including objectives, specifications and scope of work were explained clearly in the first chapter. While in the second chapter, all the related study and analysis regarding this project were included in detail to understand the key parameters in monitoring indoor air quality and other theories involved in developing the project. At the third chapter, the design methodology of the IAQ display unit using Arduino was explained step by step in a detail manner. For further project development, testing and realization, it is covered thoroughly in Chapter IV and the last chapter, Chapter V, consists the conclusion of this thesis and some suggestion and opinion for future work.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

In this chapter, the theories of the indoor environment, indoor pollutant sources and how it affects the human health has been studied. Next, the general air quality guidelines and indoor air quality monitoring and sensors are studied and analyzed throughout this chapter. This chapter also provides the required knowledge that made the project of developing the Indoor Air Quality (IAQ) Display Unit using Arduino possible.

2.1 Indoor Environment

Nowadays, most of people spend around 80% to 90% of their time in indoor environment. This directly and indirectly affect the health condition of human body. Since a good indoor environment can provide good indoor air quality for human health, while a bad indoor environment in the other hand can result in bad indoor air quality and further contribute to the development of dangerous and chronic respiratory disease such as heart disease, lung cancer and also asthma. Not just that, the long term period will also effect the productivity of the human being. What people need are

indoor air that is pleasant, fresh and have no negative effects on their health. (Kamaruzzaman, 2011)

2.2 Significance of Indoor Air Quality

Factors contributing to the formation and accumulation of atmospheric pollution have been widely studied. The results of these studies have result into national ambient air quality standards that address industrial and commercial emissions. Unlike common indoor air contaminants, environmental pollution is often visibly emitted from the source. Interestingly, this phenomenon has given the public the perception that risk associated with ambient pollution is substantially higher than that from indoor contaminants. The term 'ambient' refers to the outdoor air that is available to everyone. This perception implies that the building occupant may have a misconception that a greater exposure to pollutants is likely outdoors, when in reality the opposite may be true as well.

It has been recognized for several years that infectious agents are readily transmitted in indoors. However, what remains uncertain is the relationship between long-term exposures to small levels of airborne contaminants. Since the quality of air in indoor environments such as houses, apartments, and offices has been extensively studied and analyzed, the results from these studies have shown an association between complaints from building occupants and exposures to small, short-term increases in chemical and physical contaminants. (Jones, 1999)

In the last several years, a growing body of scientific evidence from researches has indicated that the air within homes and other buildings can be more easily polluted than the outdoor air in even the largest and most rapidly develop industrialized cities. In general, outdoor pollution, inadequate ventilation, building materials, combustion processes, tobacco smoke, paints, cleaning supplies, and even human activities affect the quality of the indoor air. (Chang, 2000)

2.3 Types of Indoor Air Contaminants

The identification of chemical contaminants in the indoor environment can be a little bit difficult and complex. This fact is supported by the all the diverse types of chemicals used in the manufacturing of building products that decompose and evaporate at varying rates and concentrations. Not just that, the type of activities the building itself serves, and the numerous chemical and physical substances that are introduced into the indoor environments also plays a big role. Pollutants from these sources are often difficult to quantify because they are present in relatively low concentrations, and their sources are diffused. So, in order to clearly diagnose factors contributing to poor level of IAQ, first must become familiar with the building design, ventilation system, existing and possible sources of contaminants along with associated health effects, and the building occupants' concerns and also existing health symptoms. (DiNardi, 2003)

From a chemical perspective, the indoor environment is a reaction vessel consisting of contaminants continually entering and exiting from time to time. For example, a newly built building or recently renovated area can be a primary source of volatile organic chemicals (VOCs). With the introduction of the new materials, VOCs are emitted into the indoor area, which contribute to the increasing in indoor pollution. This emission of VOCs is associated with the contaminant's vapour pressure. As the building materials age, decomposition of the materials can occur through chemical reaction such as moisture or ozone, and physical (e.g., heat and ultraviolet light) reactions such as ultraviolet (UV) light and heat, which can result in secondary VOC emissions. (Nielsen, 2001)

The specific types and concentrations of indoor air contaminants are various and depend on many factors. These factors include the type of products used in the area, the volatility of the product, the volume of material used, how the product is applied, and also the ventilation rate. Old technologies used for quantifying ambient pollution may not be feasible for indoor use. This is due to the fact that ambient monitoring equipment is costly, limited in mobility due to the size of the equipment, and the equipment often requires a large volume of air displacement. To accommodate the industrial need for portability and instantaneous measurements of surrounding air

quality, monitoring instruments are available for an assortment of indoor air contaminants and comfort parameters which are reusable, affordable, and provide real-time contaminant measurements. (Jones, 1999)

Next, indoor stressors can be categorized by their chemical characteristics. Concerning to IAQ matter, the chemical states of the sources comes from liquids, gases, and aerosols. Liquids are of interest because of their ability to volatilize and diffuse throughout the indoor space easily. Correspondingly, gases will diffuse until the molecules reaches equilibrium within the indoor space. Aerosols consist of solid or liquid particles of microscopic size in a gaseous medium, solid or liquid, that are suspended in air. The significant characteristics of aerosols that determine the hazard potential of the particles are its shape and density, in addition to the chemical properties of the material. (DiNardi, 1998)

The nature of contaminant presents mostly are an inhalation hazard to the building occupant. The inhalation of a gas or vapour, which is the primary route of entry into the body for indoor air pollutants, alone, does not imply an adverse health effect. Instead other characteristics of the contaminant are determinants of whether an adverse health effect will develop. The contaminant characteristics of interest include the water solubility, tissue reactivity, blood to gas phase partition coefficients, mass concentration, and residence time within the human body system. (DiNardi, 1998; Klaassen, 2001; Plog, 2002).

Regarding aerosols, the toxicity exhibited by the contaminant is largely influenced by the particulate's aerodynamic diameter, shape, density and water solubility. The probability that an inhaled particle will be deposited within the lungs depends on the material's success at traversing through the nasopharynx region which connects the nose and the mouth. In the average adult, particles greater than 10 micrometres (μm) in aerodynamic diameter are deposited in the nose or oral pharynx. Furthermore, smaller particles that are hygroscopic can absorb water and moisture in the humid region of the airway, thus enhancing the likelihood for deposition in the nasopharynx region. Indeed, not only does the potential for penetration into the respiratory system depend upon the aerodynamic diameter, but so does the region or location of deposition on the surface of the lung. (DiNardi, 1998; Klaassen, 2001)