INTERNET OF THINGS FOR METHANE AND CARBON DIOXIDE MONITORING SYSTEM

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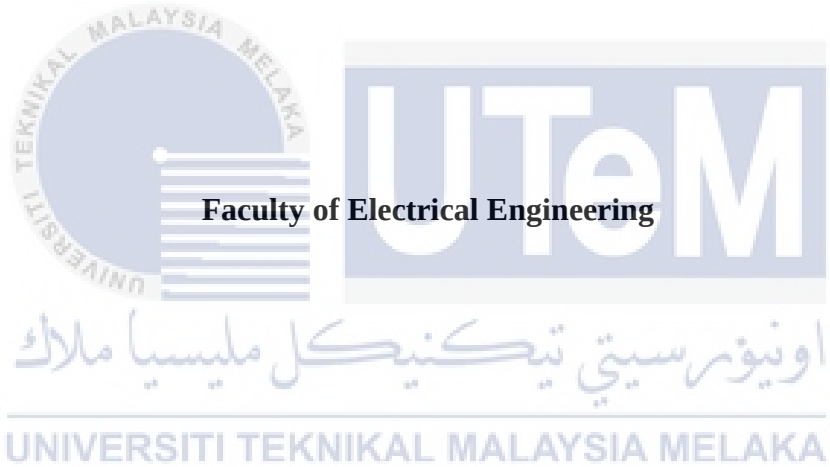
A report submitted
in partial fulfillment of the requirements for the degree of
Bachelor of Electrical Engineering with Honors



Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this thesis entitled “INTERNET OF THINGS FOR METHANE AND CARBON DIOXIDE MONITORING SYSTEM is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

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Date : 4 July 2021

APPROVAL

I hereby declare that I have checked this report entitled "INTERNET OF THINGS FOR METHANE AND CARBON DIOXIDE MONITORING SYSTEM" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours.

Signature : .....

Supervisor :

Name DR NURUL AIN MOHD SAID

Date : 5 JULY 2021

DEDICATIONS

To my beloved mother and father

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ABSTRACT

Gas detection and monitoring system have become one of the crucial matters in wide variety of field and applications which is created mostly for preventing forthcoming risk and accidents to the pollution and environment. Hence, the development of the monitoring system by using IoT integration increase the uses and advancement of the gas detection technology whether for the industries, domestic, medical and so on. This system focuses on the identification and gas concentration measurement which are carbon dioxide and methane by using MG-811 CO2 and MQ-4 methane gas sensors. The IoT integration was also implemented in the system to monitor the gas concentration at real-time monitoring system which uses an application in Android phone called Virtuino Apps and using ThingSpeak web portal. When gas is detected by the sensor and being measured, the gas concentration data displayed on the LCD display. Hence, the data of the concentration level will also be presented in the ThingSpeak web portal as real-time visualization data and pictorial statistics. The data will also be sent to the Virtuino Apps and if the gas concentration level exceeds 600ppm, the alarm in the apps will be triggered and notify the user. Both real-time monitoring system methods that have been used in the project are integrated with the IoT since they require an ESP 8266 Wi-Fi Module that linked to the mobile data network or hotspot Internet to make them operate properly.

ABSTRAK

Sistem pengesanan dan pemantauan gas telah menjadi salah satu perkara penting dalam pelbagai bidang dan applikasi yang dibuat yang mana untuk mencegah risiko dan kemalangan yang akan terjadi terhadap pencemaran dan persekitaran. Oleh itu, perkembangan sistem pemantauan dengan menggunakan integrasi IoT dapat meningkatkan penggunaan dan kemajuan teknologi pengesanan gas sama ada untuk industri, domestik, perubatan dan sebagainya. Sistem ini memfokuskan kepada pengenalpastian dan pengukuran kepekatan gas iaitu karbon dioksida dan metana dengan menggunakan sensor gas metana MG-811 dan juga MQ-4. Integrasi IoT juga dilaksanakan di dalam sistem untuk memantau kepekatan gas menggunakan sistem pemantauan waktu nyata yang menggunakan aplikasi di Android iaitu Applikasi Virtuino dan juga dengan menggunakan portal web iaitu ThingSpeak. Apabilagas dikesan oleh sensor dan diukuer, data kepekatan gas akan dipaparkan pada paparan LCD. Selain itu, data tahap konsentrasi juga akan ditunjukkan di portal web ThingSpeak sebagai data visualisasi masa nyata dan statistik bergambar. Data juga akan dikirim ke Aplikasi Virtuino dan sekiranya tahap kepekatan gas melebihi 600ppm, penggera di aplikasi akan dipicu dan memaklumkan pengguna mengenai kepekatan gas. Kedua-dua kaedah sistem pemantauan masa nyata yang telah digunakan dalam projek ini direalisasikan dengan menggunakan Modul Wi-Fi ESP 8266 yang disambungkan ke rangkaian data mudah alih atau Internet hotspot supaya sistem boleh beroperasi dengan baik.

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LIST OF SYMBOLS AND ABBREVIATIONS

IoT	-	Internet of Things
SMS	-	Short Message Services
M2M	-	Machine-to-Machine
CO_2	-	Carbon Dioxide
C3H8	-	Propane
H2	-	Hydrogen
WSN	-	Wireless Sensor Network
WSAN	-	Wireless Sensors and Actuators Network
MOX	-	Metal Oxide Semiconductor
PIR	-	Pyroelectric Infrared
IPOM	-	Integrated Pollution Monitoring
SNS	-	Simple Notification Services
NDIR	-	Non-dispersive Infrared
PPM	-	Par Per Million
CNG	-	Compressed Natural Gas
IDE	-	Integrated Development Environment
MCU	-	Micro-controller
HEX	-	Hexadecimal
ESP	-	Espressif
PM 10	-	Particulate matter less than 10u meter diameter
TCP	-	Transmission Control Protocol
IP	-	Internet Protocol
UDP	-	User Datagram Protocol
HMI	-	Human Machine Interface
MQTT	-	MQ Telemetry Transport
PLC	-	Programmable Logic Controller
HTTP	-	Hypertext Transfer Protocol

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CHAPTER 1

INTRODUCTION

1.1 Background

Gas detection and monitoring system have become essential in wide variety of field and applications which is created for preventing accidents and to provide warning about air pollution [1]. The classification of gases can reduce the forthcoming risk to the pollution and environment. Hence, the necessity of monitoring system is very essential and with the paradigm of the Internet of Things (IoT), a multi-array gas sensor that are integrated over IoT network can be developed. Internet of Things (IoT) is a rising generation of technology, the interconnection of embedded computing devices in the present internet infrastructure which permits the direct tool to device communications. In different words, it is a global gadget of "smart devices" that can sense and connect to their surroundings and interact with users and different systems.

1.2 Motivation

Carbon dioxide (CO_2) is a colourless gas with a strong odour and have a sour taste. It is one of the most significant greenhouse gases associated with the global warming that is naturally occurring and harmless when it is in small amounts, but as levels rise, it can have an impact on productivity and sleep. The most common carbon dioxide produced is by the air exhaled by the people and due to carbon dioxide indoor air concentration with less ventilation. Methane is the primary component of natural gas and is used worldwide to generate heat and electricity. Methane is also used in chemical reactions to create other important gases such as hydrogen, carbon monoxide and carbon black, a chemical compound found in some types of rubber used in automobile tyres.

Both gases are major contributor to the greenhouse gas and according to the [2], methane, the main component of natural gas, is an even more serious threat to the environment than CO2.

Gas sensing and measurement is a famous topic to the researcher and has ended up vital in various fields and applications consisting of in-home, industry, medicine, and enclosed areas supervision. Gas monitoring method had been studied for over 55 years, where it begins with the dimension of oxygen with electrochemical cells which is one of the commonplace gas sensing technology. Apart from that, a wireless sensor network has been developed to collect and send environmental data. A wireless network of small, low-cost sensors that makes it easy to monitor and control physical environments from remote locations with good precision is known as a wireless sensor network [3]. Both systems are quite old-fashioned and there is no IoT-based paradigm which can make people's matter easier. For example, when there is any leakage of gas is detected, the user or owner will be notified about the incident through SMS or call.

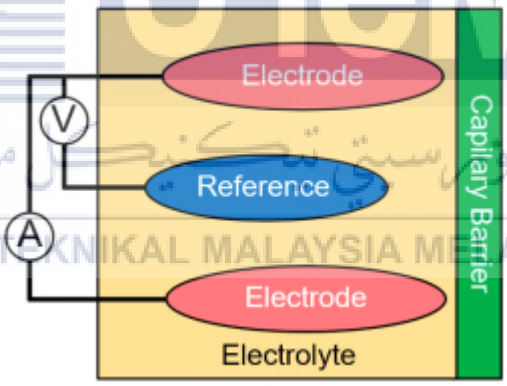

Figure 1.1: Schematics of an emperometric electrochemical gas sensor [1]

By using this method, it can avoid any incident as they can act earlier before the situation became worst. During this millennium generation, technology is an important thing in life and one of the fastest-growing innovations. Therefore, with the development of technology and the presence of smart devices, the gas detection monitoring system can be integrated by using IoT which can control and monitor the gas from far. It is important to aware people of the present gas around them by alerting

them the concentration of the gas. With the presence of the IoT-based paradigm system, gas detection can be monitored for the safety purpose which is to avoid any accident happened. It is also a way of mitigating global warming and paving the way for future generations in the coming decades to have a healthy environment.

1.3 Problem Statement

Greenhouse gases are gases that absorb heat in the atmosphere. They allow sunlight to pass through the atmosphere, but they prevent the heat that the sunlight generates from leaving. The most significant and major contributor to total greenhouse gas emissions is carbon dioxide and methane gas based on the [2] and [4]. High level of carbon dioxide, which is more than 40,000ppm can be dangerous to human life and can lead to severe health effects even death when it is in a closed space or in an indoor area. Hence, methane is highly flammable, which increases the risk of combustion given ideal situations and has a high ability to entice heat in the atmosphere. It is important to aware people of the presence gas around them by alerting them the concentration of the gas. Therefore, with the development of the technology, a gas detection monitoring system by using an integration of IoT was introduced. Even though the technology is already playing a strong role in monitoring environments where it provides immediate and actionable feedback on detected changes, but the drawback of those existed system is it does not employ a specific sensor to detect and identify the gas. For instance, a system using an MG135 gas sensor cannot determine which gas has a higher concentration since the sensor is for indoor air quality, which consists of a variety of gases such as carbon dioxide, nitrogen, alcohol, smoke and so on which has been shown in the thesis paper of [5]. Then, one alternative to overcome this problem is to develop a new monitoring system that used a specific gas sensor specifically to detect carbon dioxide and methane gas. The new structure of the system also includes for the user's interface where the user can monitor the concentration data in web portal and phone's application. The prototype is simpler since fewer components used and easy to maintain but still can have the same monitoring system performance as the conventional.

1.4 Objectives

The primary objectives of this project are:

i. To identify the methane and carbon dioxide gas that presence in the environment

ii. To measure the concentration level of methane and carbon dioxide produce by multi-array gas sensor using principal component analysis.

iii. To integrate the Internet of Things (IoT) into the system to monitor the concentration level of the gas at real-time monitoring system.

1.5 Scope

This overall project presented in the thesis is consist of two crucial parts which are software and hardware parts. The software used for this system prototype is Arduino UNO as a controller and for the hardware part, this system used several modules and devices such as sensor, LCD display, ESP8266 wi-fi module and a mobile phone to display the data at real-time monitoring system. In order to identify and measure the concentration of the carbon dioxide and methane gas, a MG-811 and MQ-4 gas sensor are used. For MG-811 gas sensor, it can detect carbon dioxide gas, which is below than 10,000ppm while for MQ-4 gas sensor, the sensor can detect from 300-10,000ppm only. ThingSpeak and Virtuino Apps also used in the system to monitor the concentration of the gas at real-time monitoring.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature reviews is some materials and research from other sources such newspapers, articles, internet and books as well. This chapter will focus on other research studies, articles, journals and case studies to discuss about the related topic that are already existed to get a deep and better understanding of the field research. This can generate some ideas on developing the final year project a successful and able to achieve all the objectives that have been outlined.

2.2 Gas Sensing Technology

Gas detection and measurement had grown to be critical in numerous fields and programs which might be for stopping accidents, warding off gadget malfunction, air pollutants warnings, granting the perfect gasoline combination to the patients in hospitals, and so forth [1]. The detection of gas leakage may be crucial to prevent all the fitness and environmental issues, now not most effective by way of alerting humans about incidents and giving them time to avoid the place but also by imparting statistics to actuators that may act that allows you to forestall the leakage and mitigate the results.

2.3 Monitoring System

Sensors have been employed to gather indicators from the surroundings, supplying information to manipulate structures for more than 2300 years, while the primary referred to system turned into evolved by using Greeks to control the level of liquids by using a floater, just like those that are used these days in water containers to keep water box at a constant stage [1]. Presently, the control system has reached a complicated level where buildings are automated to make user choices, self-driving cars and autonomous aircraft are experimented with depending on autonomous

decisions based on data generated by numerous sensors mounted on vehicles. With the presence of a tracking and controlling system in existence, it may lessen matters that concern all parties, for example, can reduce pollution levels, lower health problems and loss of life in the limit, and can prevent equipment malfunction within the enterprise discipline. Consequently, it manifestly can decorate lifestyles fine and perform higher work.

2.4 Wireless Sensor Network

The wireless sensor network (WSN) was established to improve environmental data collection, transferring process to databases, and enabling remote monitoring of areas of interest and difficult access. In addition, wireless actuators were also installed in networks called Wireless Sensors and Actuators Networks (WSANs), where it works in a collective manner to ensure automatic and intelligent decision-making on certain incidents, adapting to the changes in environment to provide first-class person experience without interference from users [1]. All through the past many years, authors have centred on proposing, writing, and the creation of wireless gas sensors for multiple programs for different fields. The primary wireless gas sensor techniques were developed for monitoring huge areas with no clear Wi-Fi protocol carried out. Consequently, that sensors transmitted the information that has been detected thru satellite tv for pc networks or bands through easy modulation strategies. Currently, there were a whole lot of different structures that have been proposed to fulfil the call from numerous fields for monitoring of gas sensing technology.

2.4.1 Real-time indoor carbon dioxide monitoring through cognitive wireless sensor network

This project was developed for monitoring carbon dioxide and detect the carbon dioxide gas concentration at complex indoor environment by using a real-time cognitive wireless sensor networks [6]. In addition, air quality warnings, such as carbon monoxide (CO), nitrogen dioxide (NO_2) and carbon dioxide (CO_2), are also issued in a timely manner. This thesis focuses mostly on the monitoring of carbon dioxide in indoor applications. This scheme is applied through a network of wireless

sensors. To reduce interference with other systems in the monitoring place, each node within the network has two antennas and follows cognitive networking strategies.

Then, the packets' routing protocol from the sources to the control room would follow an opportunistic approach to routing. Thus, depending on the needs of the application, the nodes may join or leave the network while there is no pre-existing infrastructure [6]. By using carbon dioxide sensors that are then combined with radio modules to form wireless monitoring nodes, the user obtains real-time information and all the information obtained is transmitted to the radio and then transmitted to the control room. Through the usage of this method, it can be a perfect strategy to get for low-cost nodes that can integrate sensing, data processing, packet information in addition to wireless transmission as it may be a manner to reduce the intrude with the existing networks in the tracking area.

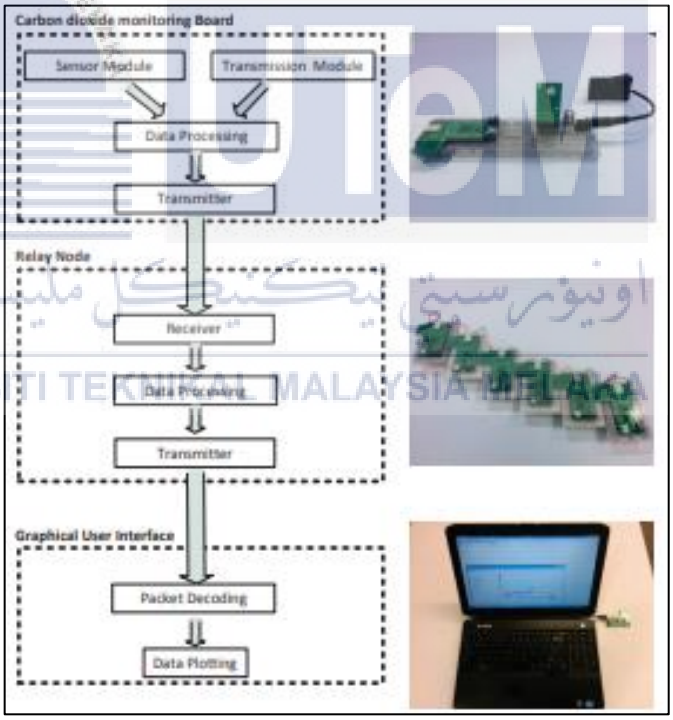

Figure 2.1: Overview of the monitoring system [6]

2.4.2 Context-adaptive multimodal wireless sensor network for energy efficient gas monitoring

This project presented a multimodal network that, as seen in [7], obtains information from a metal oxide semiconductor (MOX) gas sensor and a pyroelectric infrared (PIR) sensor. Energy efficiency is a major concern in such a network since gas sensors are power-hungry and the sensor node must run on a battery power supply unattended for many years. A MOX gas sensor is used at the sensor level to measure the gas concentration for indoor air quality monitoring. The ZigBee coordinator nodes are therefore equipped with a very low sleep current, which is only 8uA, to decrease energy consumption.

Furthermore, this project reduces the activity of nodes and the MOX gas sensor by using information from the PIR sensor about the humans' presence and warning messages from other nodes in the network. Simulation of the application scenario reveals that with only 2A batteries, the solution extended the lifespan of the network to many years. It demonstrates that the use of this proposed solution improves the durability and reliability of the network to reduce the power consumption of pulse operating node MOX sensors. Besides that, avoiding power wiring and associated facilities can save time and money.

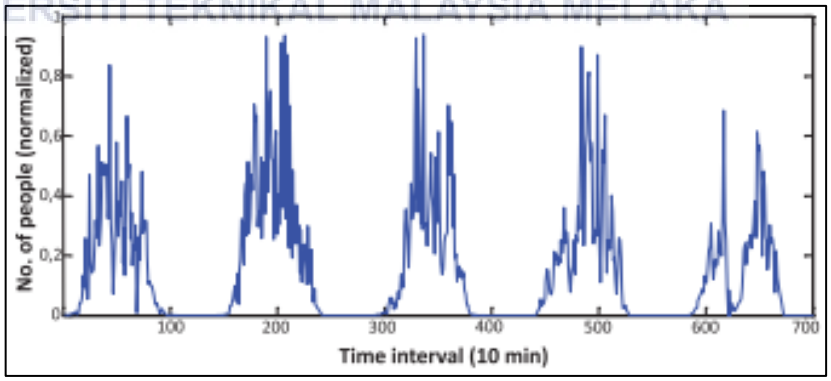

Figure 2.2: Number of people detected by PIR sensor within five days [7]