Haze Monitoring System in City of Kuala Lumpur using Zigbee Wireless Technology Implementation

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***Abstract*— Despite with the current policies to reduce hazardous particle emission, global emission is still expected continue to grow over the coming decades. Over the course of the 21st century, the increase in emission at or above their current rate would very likely induce changes in the climate system larger than those observed in the 20th century. Haze is traditionally an atmospheric phenomenon where dust, smoke and other dry particles obscure the clarity of the sky. Haze often occurs when dust and smoke particles accumulate in relatively dry air. When weather conditions block the dispersal of smoke and other pollutants they concentrate and form a usually low-hanging shroud that impairs visibility and may become a respiratory health threat. A new method of collecting data for haze based environment using Zigbee technology and its design method of software and hardware is developed in this paper. MQ2 sensor and PIC16F887 are used for data collection collected and transmitted through Zigbee wireless technology to a personal computer. The data is then processed by digital computer to classify according the level of air pollutant index.**

***Index Terms*—Zigbee, PIC16F887, MQ2, haze.**

I. Introduction

A. Haze

HAZE is traditionally an atmospheric phenomenon where dust, smoke and other dry particles obscure the clarity of the sky. The World Meteorological Organization manual of codes includes a classification of horizontal obscuration into categories of fog, ice fog, steam fog, mist, haze, smoke, volcanic ash, dust, sand and snow. Sources for haze particles include farming (ploughing in dry weather), traffic, industry, and wildfires.[1]

Haze often occurs when dust and smoke particles accumulate in relatively dry air. When weather conditions blocks the dispersal of smoke and other pollutants they concentrate and form a usually low-hanging shroud that impairs visibility and may become a respiratory health threat. Industrial pollution can result in dense haze, which is known as smog.

Sim Leol Leol and Christopher Tan reported in The Star, *8 September 2011*, people with respiratory problems have been advised to stay indoors and take precaution after air quality worsened in most parts of Malaysia, with Klang Valley recording poor visibility and moderately bad air quality. The haze caused by the overnight increase of hotspots from 62 to 120 in Sumatra, Indonesia, caused the sky in Klang Valley and other cities and towns to be overcast. Most areas around the city as well as certain northern states also recorded a drop in visibility levels.

The Klang Valley recorded poor visibility and moderately bad air quality where the reading shows for Petaling Jaya rose to 86ppm from 79ppm while that for Shah Alam was at 90ppm close to unhealthy levels.[2]

B. Wireless system

Wireless sensor network can be used in a dedicated situation for signal collection, processing and transmitting. Zigbee is a wireless sensor network technology characterize for close distance and low speed. It is a wireless network protocol stack of IEEE 802.15.[3]. Adopting wireless is more convenient and economical since it offers flexibility and mobility to save cost and energy spent on wiring. The framework of the hardware, software structure, and programming with the implementation of Zigbee technology offers advantages such as low cost, low power and wider coverage.

This system is the non contact and non line-of-sight that can be read several meters away thus reduces the need for manual scanning and easier in data transportation. This is achieved by implementing two Zigbee transceivers which are used for transmitter and receiver. The transmitter will emits a signal and periodically send the data from the memory of microcontroller PIC16f887. The microcontroller performed the necessary calculation and sent it to a receiver. By using the UART port of the receiver, the data will be sent to the computer serial port via Universal Serial Bus (USB) and continuously displays on the computer until the connection at the HyperTerminal is put to a halt.

Manuscript received May 08, 2012; revised May 08, 2012. This work was supported in part by the RMI of UiTM under Grant RMI213/2011.

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ISBN: 978-988-19252-8-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

II. METHODOLOGY

This project is comprised of hardware and software development. The overall block diagram of the haze system monitoring is shown in Fig 1 that consists of gas sensor, transmitter, receiver and display.

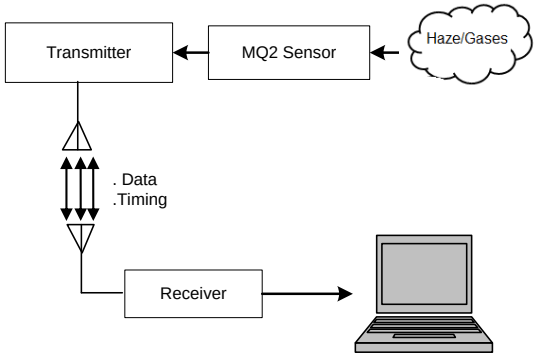

Fig 1. Block diagram of data collection process.

A. Hardware Development

Fig 2 shows the block diagram used for the transmitter. The input of the transmitter is the MQ2 gas sensor. The processed data output will be transmitted by the PIC16f887 through the Zigbee wireless transceivers.

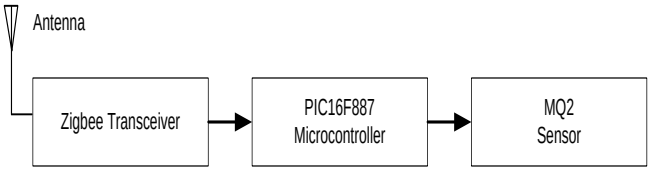

Fig 2. Block diagram of a transmitter.

Fig 3 shows pin configuration of the PIC16F887 microcontroller, MQ2 sensor is connected to the I/O port on the microcontroller's Port A (RA0 or pin 2). While the output port is connected to the Zigbee transceiver UART port in pin Tx (pin 25) and Rx (pin 26).

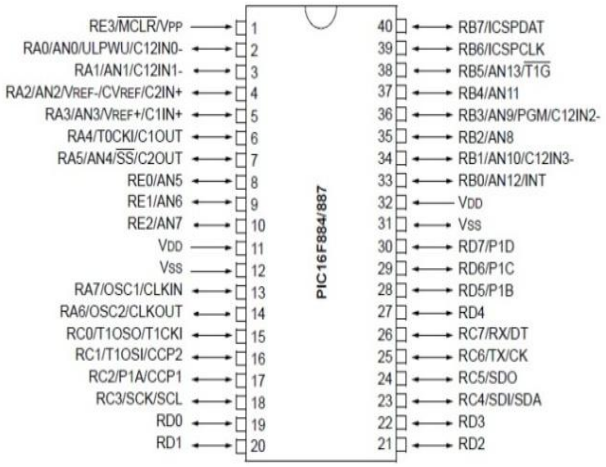

Fig. 3 Pin configuration of PIC16F887 microcontroller

The microcontroller is loaded with a program using PIC programmer board written in assembly language. The program consists of instructions that accept data from the MQ2 sensor to be calculated accordingly and send the signal to the UART port.

Fig 4 is a block diagram of the transmitter circuit showing the voltage regulator LM7111 to supply 5 volt to the microcontroller PIC16F887, MQ2 sensor and Zigbee transceiver. Haze/smoke particles detected by the MQ2 sensor is treated as a voltage input for the microcontroller to process and translate into meaningful data and later transmitted by Zigbee to display device.

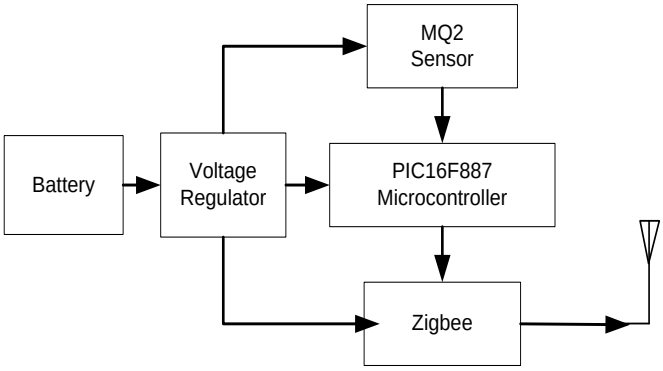

Fig 4. Block diagram of transmitter circuit.

The Zigbee transceiver has an operating frequency of 2.4GHZ and suitable for indoor and outdoor communication applications. Indoor communication allows for range up to 30m and outdoor line of sight is up to 100m. Zigbee transceiver is designed with capabilities and features of USB Plug and Play UART function and 5 Volt UART for microcontroller interface. The device can either be connected to the microcontroller or PC as shown in Fig 5.

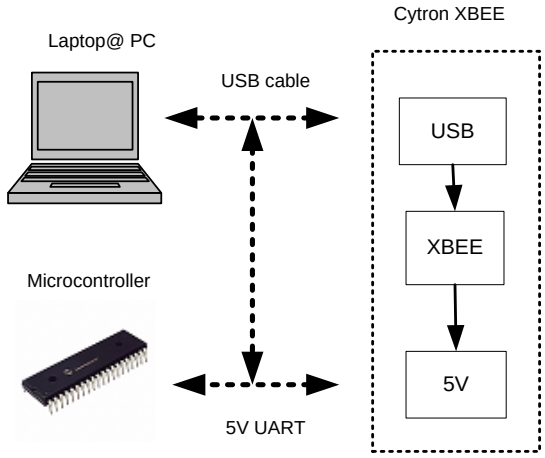

Fig 5. Zigbee transceiver system overview

ISBN: 978-988-19252-8-2
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

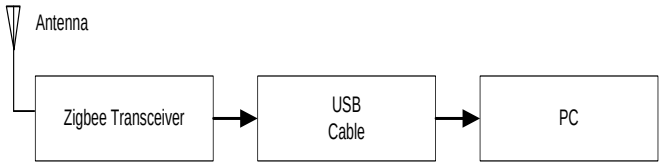

Fig 6. Block diagram of a receiver

Fig. 6 shows a block diagram of receiver used in the project. The receiver is a data gathering terminal connected to a personal computer consists of Zigbee transceiver module and display device.

B. *Software Development*

PIC16F887 microcontroller requires software driver to perform necessary action. The software program is written in assembly language using 32-bits MPLab IDE embedded system platform and uploaded into the microcontroller memory using the PIC2kit. Fig 7 shows the program flow chart of the microcontroller.

Basically, the microcontroller is programmed to accept data from the sensor, processed and classified it based on data in Table I to be displayed on a display module such as personal computer or laptop. Table I shows the Air Pollution Index or (API) scale designed to help understand the impact of air quality on health. The reading process is continuously updated until the system is put to a halt.

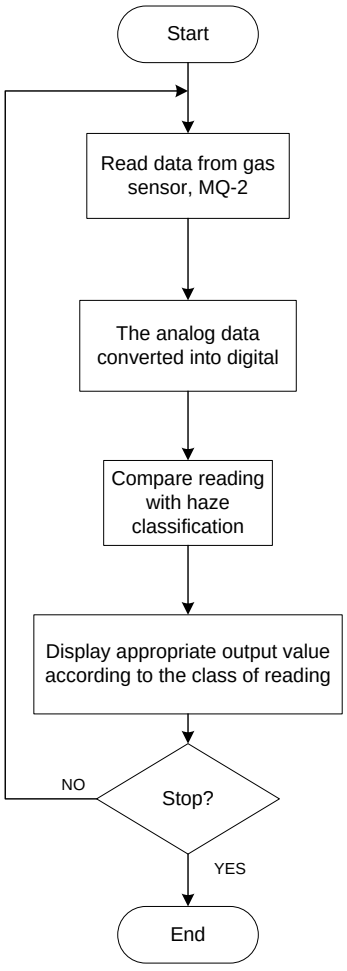

Fig 7 Flow chart of microcontroller program

Table I API classification to level of health

Air pollution Index (ppm)	Condition
0 – 50	Good
51 – 100	Moderate
101 – 200	Unhealthy
201 – 300	Very unhealthy
301 above	Hazardous

III. System Testing

A. *Hardware Components*

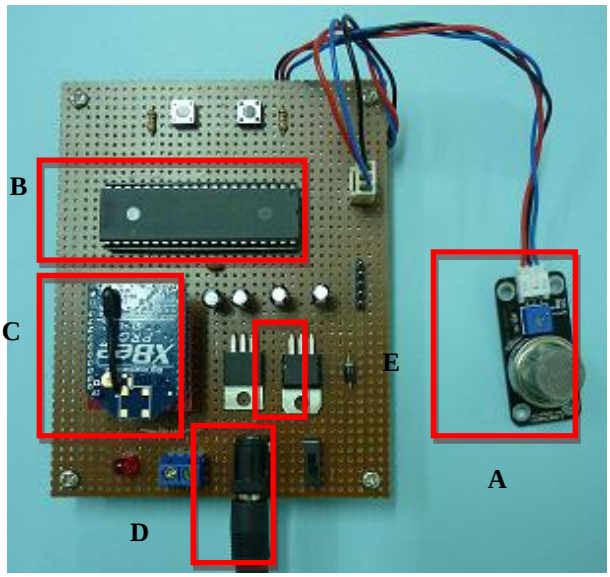

Fig 8. Transmitter hardware

Fig 8 shows the hardware for zigbee transmitter. Section label A is the gas sensor while B is the microcontroller. And sections label C, D, E are the Zigbee transceiver, power supply and voltage regulator respectively.

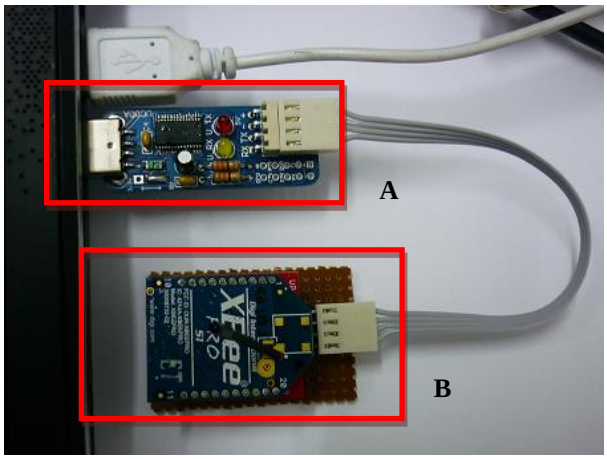

Fig 9. Receiver hardware

Fig 9 shows the hardware for zigbee transmitter. Section label A is the USB port and B is the Zigbee transceiver.

ISBN: 978-988-19252-8-2
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B. *Testing method*

The completed system is put for testing in selected different area in the city of Kuala Lumpur. Five areas have been selected as the test area for data collection. These selected areas are known to be congested with vehicles are the Kuala Lumpur City Center (KLCC), Pudu Raya, Jln Tuanku Abdul Rahman (JLN TAR), Perdana Lake Garden and KLCC parking area.

Gas emission from vehicles was mainly the contributing element in the data collection. All of the tests were conducted by placing the gas sensor in the vicinity of 50 meters in each area. Data is taken in three time slots defined as 1st time slot is from 9.30am until 10.30am, 2nd time slot is from 1.30pm until 2.30pm while 3rd time slots is from 5.30pm until 6.30pm. The chosen time slots are based on the time at which people doing a lot of activities involving commuting using their vehicles.

The sensor is applied to read and measure the haze level of the respected area. Among many, some of the results of the testing are reported here.

IV. Results

Fig. 10 is a plotted graph showing the haze reading in Pudu Raya area. The highest reading recorded was 332ppm during the first 30 minutes and this justify the area was in a heavily pollutant level. The probable reason is due to the high number of vehicles in the area during peak hour and most of the city dwellers were heading towards their work place. Moreover, Pudu Raya is the hub station for the city's public transportation such as buses and taxis.

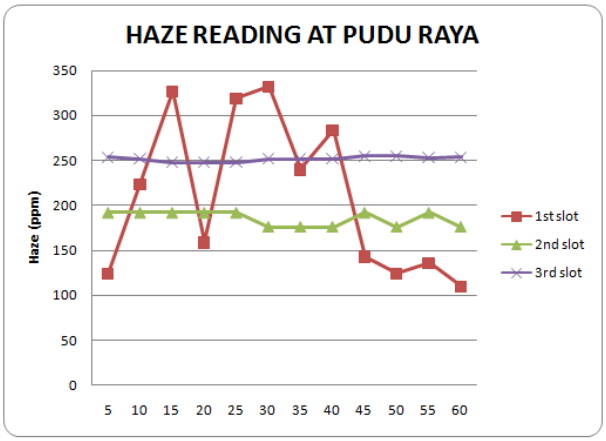

Fig 10. Plotted graph of haze at Pudu Raya.

Result for JLN TAR is shown in Fig 11. In this area, the data also showed significant unhealthy level of air pollutant. The recorded average reading was 192 ppm that due to the fact that JLN TAR is a busy shopping street that welcomes a lot of visitors every day and also one of the most popular street for people to exit from the Kuala Lumpur city. During the testing period, it can be observed that a lot of vehicles passing through the street.

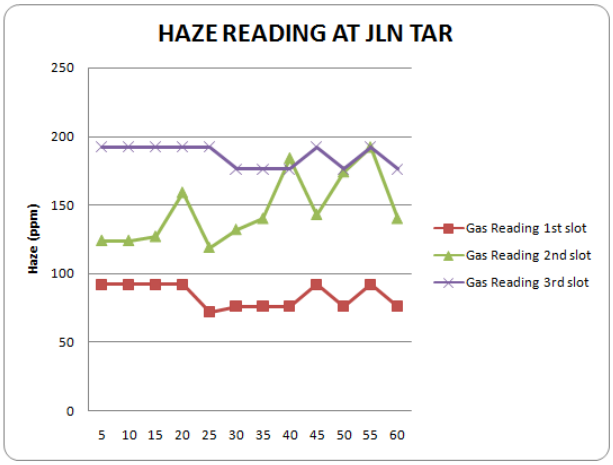

Fig 11. Plotted graph of haze at JLN TAR.

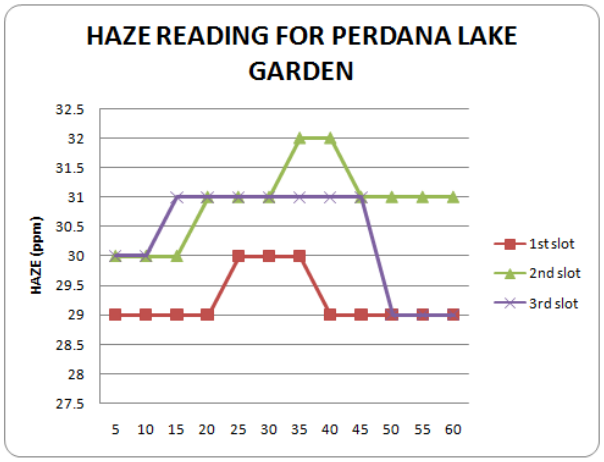

Fig 12. Plotted graph of haze at Perdana Lake Garden

Similar test at Perdana Lake garden has been conducted and the result is depicted in Fig 12. From the figure, Perdana Lake garden showed a good level of haze reading. During the experiment, it can be observed that the number of vehicles is far less than the previous two areas tested before. Besides that, the lake garden is an area for recreation with lots of trees and green plantations.

Further analysis is performed by comparing the result obtained from the three different areas selected in this study as shown in Fig. 13. The time slots from 5.30pm until 6.30pm is selected because this is the peak hour for the city dwellers commuting from one location to another. For the three selected areas in the city of Kuala Lumpur, PUDU RAYA is with the highest air pollutant level followed by JLN TAR and Perdana Lake garden having the lowest air pollutant level.

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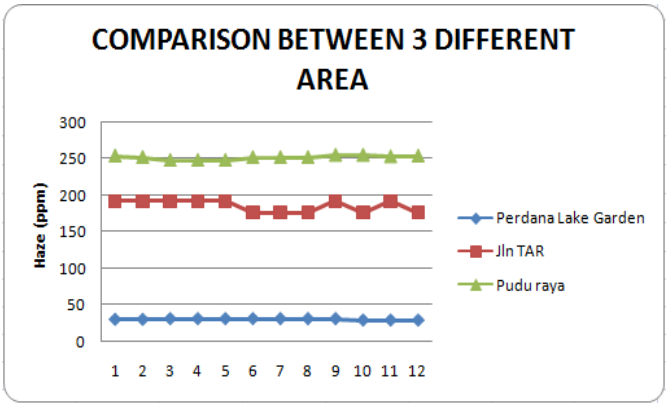

Fig 13. Plotted graph of data from the three different areas in Kuala Lumpur taken from 5.30pm until 6.30pm

V. Conclusion

This paper presents a wireless sensor networks system using Zigbee technology for haze monitoring. Testing proved that in the area with lots of vehicles, haze reading is very unhealthy. The data collected can be a useful component to give awareness to the public safety. The experiment showed that the wireless technology can be used to alert the public about the safety of air quality. The development of this project can be implemented to give the public precautions step to avoid from having any outdoor activities if the level of air is hazardous. Besides, the developed system is low cost and low power to be implemented in the city of Kuala Lumpur.

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