Breathing Air Level Transmitter Monitoring

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to

Electrical and Electronics Engineering Programme

Universiti Teknologi PETRONAS

in partial fulfilment of the requirements for the

BACHELOR OF ENGINEERING (Hons)

(ELECTRICAL AND ELECTRONICS)

Approved:

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TRONOH, PERAK

September 2014

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MUHAMMAD NAZRUL BIN KAMARUL BAHARIN

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ABSTRACT

This paper presents about a monitoring device that can monitor the level of oxygen in fire fighter oxygen tank during rescuing operation. In savings other people life, fire fighters have to risk everything in order to accomplish the mission. The safety of the fire fighters sometimes is compromised in order to save someone in a burning building or in a burning forest. Any kind of assistance in term of new technology to monitor the condition of fire fighter during rescue mission is necessary and important to the fire fighters community. Oxygen is important to human and continuous supply of oxygen in critical condition during rescue mission is needed for fire fighters in order to perform their rescue operation efficiently. The monitoring system is done by measuring the pressure of oxygen inside the oxygen tank and transmits the data to the computer. The computer will analyse and display the real-time value of oxygen on the screen. An alarm will be displayed if the oxygen pressure drops below warning level so that the fire fighter can take immediate action by evacuating the danger area before the oxygen runs out. The system also is equipped with a Carbon Monoxide (CO) sensor that will monitor the surrounding air carbon monoxide gas concentration. Carbon monoxide is a harmful gas and if humans are exposed to high concentration of CO in the air, it will lead to fatality. This paper also will discuss the method of transferring the data from the oxygen tank using Zigbee protocol wireless technology since it is more convenient for low-power transmission data. Wireless technology is important nowadays as it proves to be a more efficient ways to communicate and transmitting data compared to using wired devices. Zigbee is the latest wireless technology introduced to the world and proves to be a more sophisticated system compared to Wi-Fi and Bluetooth

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LIST OF ABBREVIATIONS

CO	Carbon Monoxide
POS	Personal Operating Space
IDE	Integrated Drives Electronics
NFPA	National Fire Protection Association
SCBA	Self- Contained Breathing Apparatus
MEMS	Micro Electromechanical System
RF	Radio Frequency
CH_4	Methane
FYP	Final Year Project
SEDEX	Science and Engineering Design Exhibition
IEEE	Institute of Electrical and Electronics Engineering
PCB	Printed Circuit Board
USB	Universal Serial Bus
UART	Universal Asynchronous Receiver/Transmitter
MY	Source Address
DL	Destination Address Low
ATM	Atmospheric Pressure
ADC	Analogue Digital Conversion
PPM	Part Per Million
UTP	Universiti Teknologi PETRONAS

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND STUDY

Fire fighter is one of the most noble and important job in the world. Rescuing and saving people lives are one of the tasks of fire fighters. Apart from saving people from fire, fire fighters are needed in other serious cases such as handling hazardous material accidents and involved in search and rescue operation when natural disaster strikes [1]. New technology being developed every day in order to assist fire fighters to conduct their rescue missions. Since the work of fire fighters is dangerous and can involve fatality, a monitoring system is needed in order to monitor the condition of the fire fighter involved in the operation. Safety of fire fighters in any operation is essential in order for the operation to be succeeded with minimum injury or fatality. One of the monitoring aspects that need to be done towards their rescue mission is the monitoring of oxygen level in the oxygen tank that fire fighters carry while conducting operations. Fire fighters use the oxygen tank to supply oxygen when entering area filled with smoke that causes difficulty to breathe. The oxygen is supply through the oxygen mask that needs to be worn at all time by the fire fighters. This project aim is to design and develop a monitoring system that is able to monitor the oxygen level in the oxygen tank of each fire fighters and it will give distress signal when the oxygen is below the predefined limit. The system also is equipped with an additional Carbon Monoxide (CO) monitoring system to monitor the surrounding concentration of Carbon Monoxide (CO) gas.

1.2 PROBLEM STATEMENT

There are several cases where fire fighters died while performing their rescuing mission and fire fighting operation. In 2012, 22 fire fighters were killed during an operation and the statistics shows that 47.2% of nature of fatal injury is from heart attack [2]. Lack of oxygen in the body will lead to serious diseases that caused fatality such as stroke and heart attack. Fire fighters all around the world are exposed to these risks if no proper action is taken to prevent the problem. In 2000, one fire fighter fell unconscious and died several hours later after trying to extinguish a burning house in South Ozone Park due to depleted oxygen canister that the fire fighter wore on his back while performing the rescuing mission [3]. Similar case was occurred in 2010 where a 50 years old fire fighter died during operation to rescue a utility worker in a sewer due to low oxygen level in the sewer and inhalation of sewer gases. These fire fighters are being monitored on real time basis from the fire engine room and stress signal is sent when needed. Some variable such as the level of the oxygen in the oxygen tank and heart rate is very crucial in determining the condition of the rescuer. Fire fighters are given around less than 30 minutes to do their rescue mission because the oxygen in the tank can last up to 30 minutes before it finish [3]. Therefore, this project will focus on creating a monitoring system of oxygen level inside the oxygen tank that will monitor the oxygen inside the oxygen canister and transmit a signal to a control centre that will monitor the level of oxygen inside the tank being used by the fire fighter. The problems that leads to conducting this research are:

1. Fire fighters does not aware of the level of oxygen in the tank
2. No monitoring system in place to monitor the level of oxygen in the tank and Carbon Monoxide (CO) during operation in fire
3. No alert system to notify the fire fighter on the level of oxygen and Carbon Monoxide (CO) status

1.3 OBJECTIVES

The objective of this project is to develop a monitoring system that can monitor level of oxygen gas in an oxygen tank that will be used by fire fighters during their operations. The monitoring is being done by providing a real-time reading from the oxygen tank being used to the system in the computer and it will trigger an alarm if the oxygen level drops below the warning level. The system also can notify the fire fighter that the oxygen level in the tank is dropping below warning level so that the fire fighter can take proper action by leaving the rescuing area to avoid unwanted accident [3-5].

The transmission of the pressure data from the tank to the system will be done wirelessly by using ZigBee protocol due to its reliability to transmit big information using personal operating space (POS) and mesh networking and it also uses minimal amount of power, suitable for low-power circuit such as data transmitting circuit [6].

Therefore, the objectives of the project can be summarised as follows:

1. To develop a new oxygen monitoring product while maintaining the design of the oxygen tank.
2. To transmit real-time pressure data from the tank to the system wirelessly.
3. To alert the control centre and the fire fighter when oxygen is running low

1.4 SCOPE OF STUDIES

This project will be using both software and hardware to set up the system. Some of the components that will be used for this project are pressure transducer, Carbon Monoxide (CO) sensor, Zigbee modules, 9V batteries and Arduino microcontroller. The software part that involved in this project is the Arduino IDE, X-CTU, and Processing. Figure 1.1 shows the process flow for oxygen detection method.

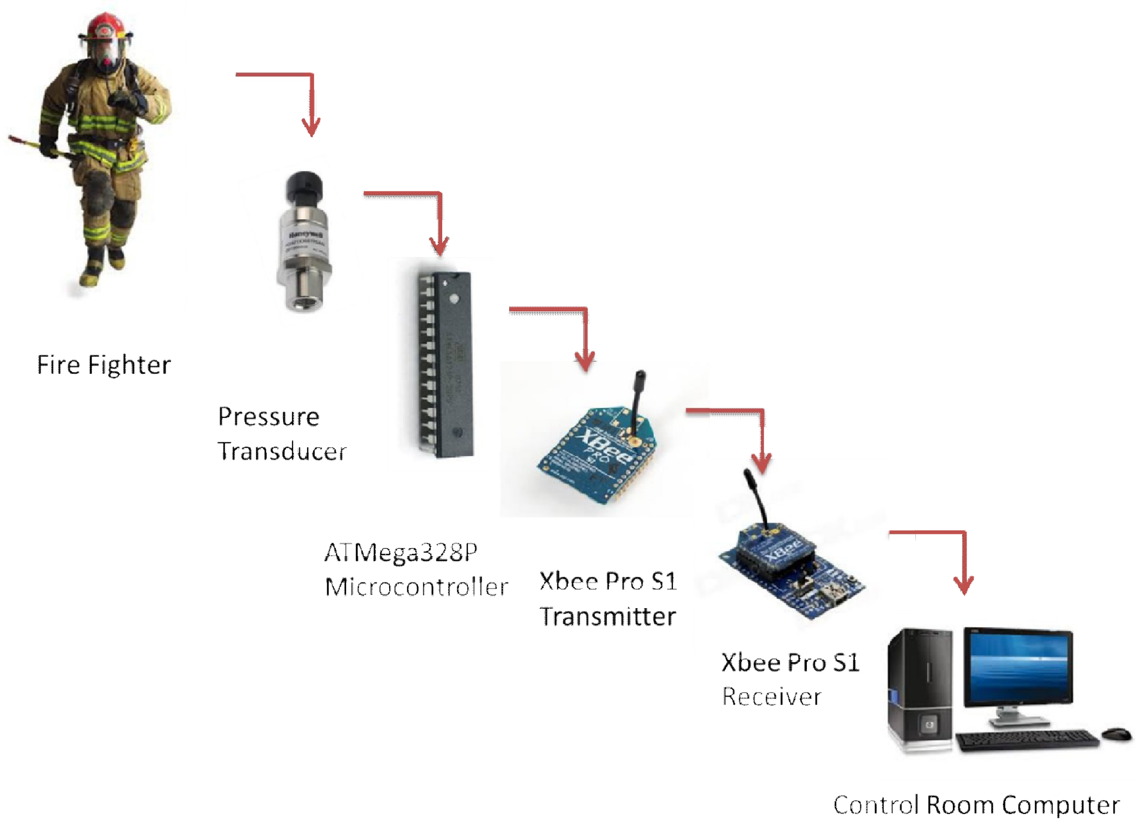

FIGURE 1.1 Flow of the Project for Oxygen Sensor

The pressure transducer will measure the pressure of oxygen inside the tank continuously and will send the data to the Xbee Pro S1 to be transmitted the Xbee Pro S1 receiver. The Xbee Pro S1 receiver will process the data received to be displayed by the X-CTU software. If the level of oxygen is normal and higher than the warning level, the X-CTU will not display a warning sign to notify the operation supervisor about the running low of the oxygen tank used by the fire fighters. If the level is below warning level, the X-CTU will display warning sign to notify the operation supervisor of the current oxygen level and can plan for evacuation action for the fire fighters. Figure 1.2 shows the process of CO detection in the system

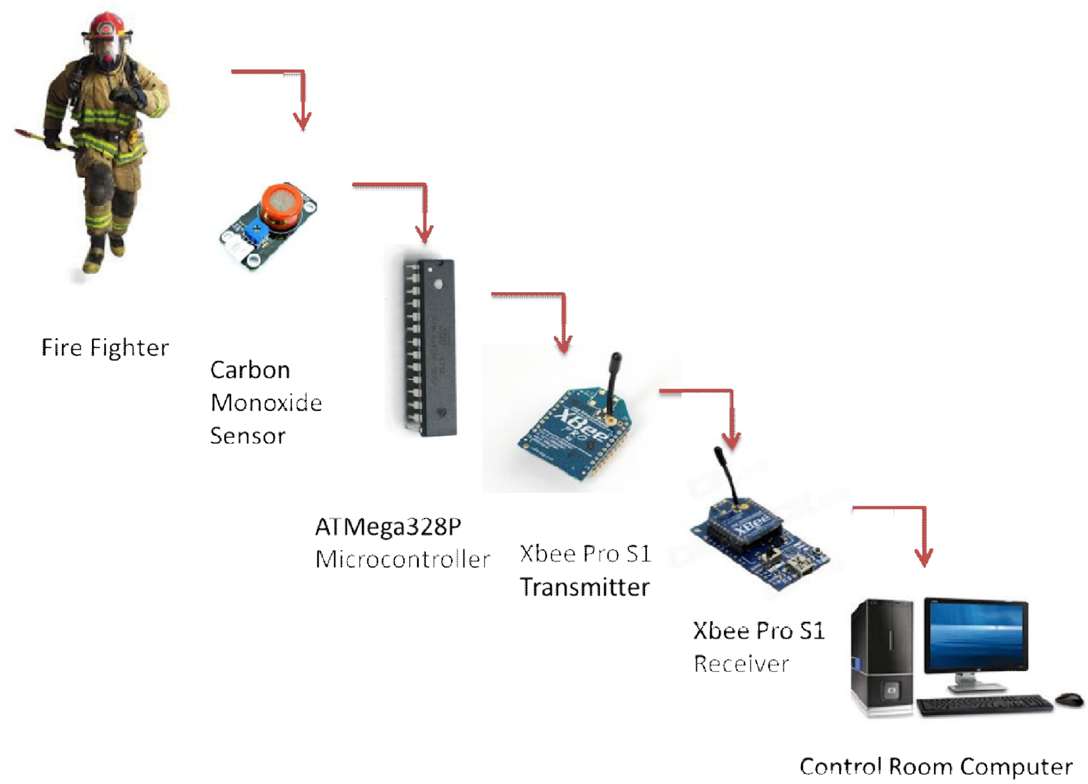

FIGURE 1.2 Flow of the Project for CO Sensor

For the Carbon Monoxide (CO) sensor, it will measure the concentration of CO gas in the surrounding area and send the data to the Xbee Pro S1 transmitter to be transmitted to the receiver part. After receiving the data, Xbee Pro S1 receiver will process the value recorded to be displayed at the X-CTU serial monitor. If the value of CO in the surrounding area is low, no alarm will be displayed. If the CO level in the surrounding area is high, an alarm will be displayed to notify the fire fighter about the situation.

CHAPTER 2

LITERATURE REVIEW

2.1 CHAPTER OVERVIEW

Cases where fire fighter died on duty due to lack of oxygen or Asphyxiation (smoke inhalation) have occurred all around the world [3]. Statistics from National Fire Protection Association (NFPA) shows that in 2013, 40% fatality of fire fighters on duty is from sudden cardiac arrest [7]. Empty oxygen tank will cause the fire fighter to inhale the surrounding air that filled with hazardous gases and smoke that can affect the lung and heart. Low level of oxygen inside the blood will cause the human immune system to weaken and eventually fail [4].

The same source of statistics also shows that 24% of 2013 fatality of fire fighters is caused by Asphyxiation (including smoke inhalation), which is the 2nd highest nature of fatal injury of fire fighters in 2013. Smoke inhalation is harmful due to dangerous gases inhaled can cause stroke or cardiac arrest. Fire fighters experiencing this symptom usually will fell unconscious and died few hours later [3]. Figure 2.1 shows the percentage of death by nature of injuries.

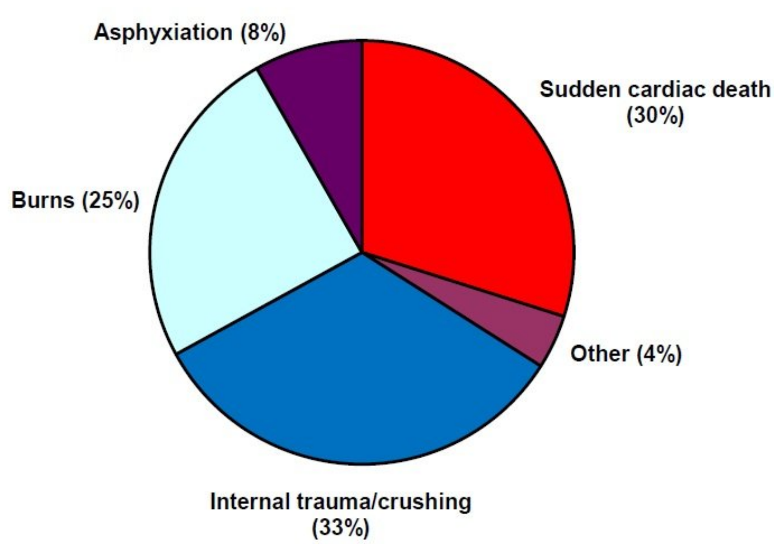

FIGURE 2.1 Statistics of Fire Fighters Death by Nature of Injuries[7].

The common type of breathing apparatus worn by fire fighters during the rescue operation is the Self-Contained Breathing Apparatus (SCBA). The SCBA is a tool that supply oxygen from the oxygen tank to the mask that covers the whole face with transparent visual display and also equipped with sensors that give feedback to the fire fighters [8]. Fire fighters are required to wear the SCBA during rescue operation to protect themselves from harmful gases and smoke and also to ensure clean air is breathe. The oxygen inside the oxygen tank usually can last up to 30 minutes but it is advisable for fire fighters to use it for only 20 minutes to avoid oxygen depletion [3]. Figure 2.2 shows one of the face mask used in SCBA.

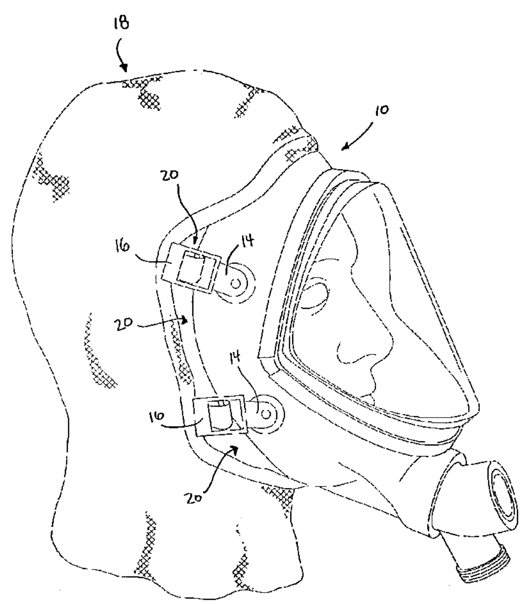

FIGURE 2.2 Face Mask for SCBA [9]

2.2 OXYGEN LEVEL MONITORING TECHNIQUE

Research about firefighting technology has been conducted widely and actively all around the world in order to produce the most sophisticated technology to assist fire fighters to conduct their rescue missions. Oxygen level monitoring is one of the technologies being tested in order to produce a system that helps fire fighter to perform the search and rescue operation successfully. There are some researchers have conducted similar research regarding oxygen monitoring level for medical purposes.

The pressure of oxygen cylinder in hospital were measured using the MEMS pressure sensor that will send amplified real-time pressure data from the oxygen cylinder to the viewing station located at the hospital[4]. The sensor was designed to detect the pressure at the upper part of the oxygen tank head and send the data received to the RF transmitter before it transmit the data to the receiver at the computer where the monitoring is being done. For low power application, the system used SX 150 pressure sensor to calculate the differential pressure from the oxygen tank where the sensor convert the pressure calculated to output voltage accurately before amplify it using LM 324 operational amplifier. The purpose of operational amplifier is to amplify the output voltage from the sensor due to its output that is in millivolts (mv).

Another system that was developed to monitor the oxygen level in a patient oxygen tank uses the pressure released by the oxygen tank to generate an audible alarm that will notify the patient and the doctors if the pressure inside the oxygen tank is running low [5]. The system use a spring that will open and close a hole in the adapter, depending on the strength of the pressure applied to the spring. The adapter will be place at the outlet of the oxygen tank and when the pressure inside the tank is greater than the atmospheric pressure, the air cannot flow into the nozzle where the spring is located, thus preventing an opening for the audible sound to occur. The audible sound can only be heard when the pressure inside the tank drops and the atmospheric pressure is higher and allowing air to enter the nozzle, therefore producing sound[5]. Figure 2.3 explains the operating principle of the system.

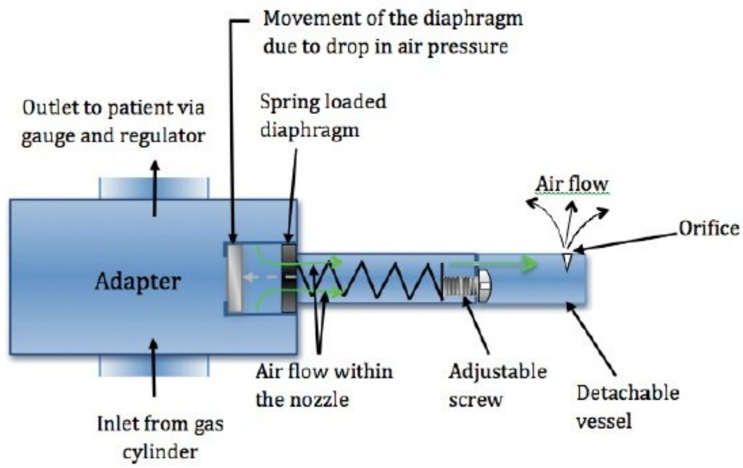

FIGURE 2.3. The Operating Principle of the Audible Alarm System [5]

A more sophisticated technology was developed by MacDermott[10] where removable monitoring systems that can be connected to the outlet of the oxygen cylinder to the pressure regulator to monitor the oxygen pressure inside the cylinder. The system uses electronic pressure sensors to monitor the level of oxygen inside the tank and also will notify the user or the control centre visually and verbally if the pressure inside the oxygen cylinder drops below warning level [10]. An automatic monitoring alarm adjustment system for oxygen and compressed air delivery cylinders were developed by Harvie [11]. The automatic system will measure pulse and blood oxygen concentration [12]level to calculate the level of oxygen inside the cylinder and thus, giving the user exact time on how much time left the oxygen cylinder can be used before it runs out of oxygen[11].

All of the devices developed uses external power source to power the circuit of the monitoring system because continuous reading of the pressure is needed in order to notify the user when the pressure have reached warning or exceed below the warning level. Therefore it is essential to use high efficiency battery in order to supply the systems with power continuously.

2.3 WIRELESS SYSTEM: ZIGBEE AND ARDUINO

New technology being developed nowadays to enhance the data transmission using wireless technology. Wireless technology is much more simple and cost-saving and can transmit better data for monitoring purposes [13]. Zigbee technology is the latest wireless technology being develop that is much more reliable and easy to control for data transmitting [6]. Integrating sensors with Zigbee is a challenging task due to the continuous amount of data that needs to be transmitted all the time and the continuous supply of power has also been an issue in this case [14]. Zigbee also is considered a better choice in the industries due to its wider choice that meets the industrial demands compared to Bluetooth technology [6]. Table 2.1 shows the comparison between Zigbee, Bluetooth and Wi-fi.

TABLE 2.1 Comparison Between Bluetooth,Zigbee and Wi-Fi Technology[6]

Specification	Bluetooth	Zigbee	Wi-Fi
Frequency	2.4 GHz	868/915 MHz; 2.4 GHz	802.11a/b/g
Maximum signal rate	1 Mb/s	250 kb/s	54 Mb/s
Range	10 m	10-100 m	100 m
Normal transmitting power	0-10 dBm	(-25)-0 dBm	15-20 dBm
RF channels available	79	1/10;16	14(2.4 GHz)
Bandwidth of channel	1 MHz	0.3/0.6 MHz; 2MHz	22 MHz

The data in the table shows the specification of each wireless technology available nowadays. From the table also, Wi-Fi technology is much better technology compared to Bluetooth and Zigbee. For application that uses low power and small data transmitting, Zigbee is the ideal technology [10]. The data from the pressure sensor does not require a huge bandwidth and high signal rate. Zigbee wireless network is essential to be used to measure the pressure of the oxygen inside the oxygen tank because of its capability to use enormous numbers of wireless nodes that will automatically adjust themselves [10]. Therefore, there is no doubt that this project will be able to transmit accurate data to the computer within short period of time.

Zigbee can be integrated with Arduino microprocessor to create the wireless system sensor. The output from the sensor need to be processed before it can be transmitted by Zigbee to the computer. Arduino is responsible to process all the data before integrating it with a module the follows XBee communication protocol [13]. Figure 2.4 shows the Arduino board used in making the prototype.

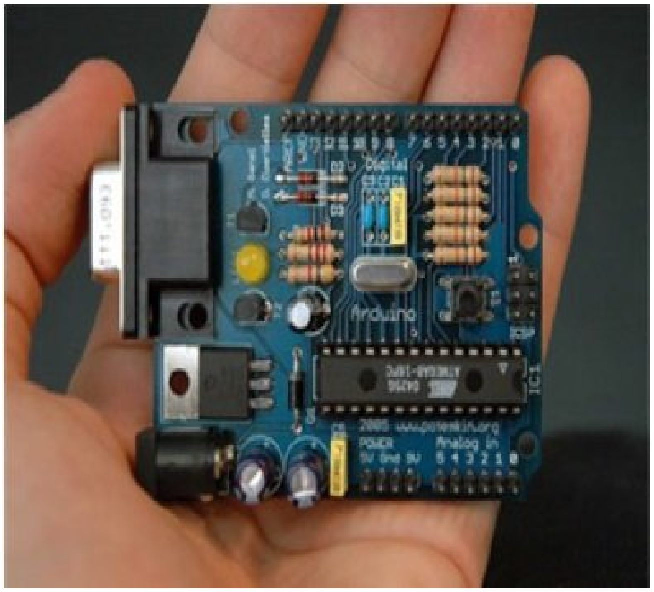

FIGURE 2.4 Arduino Board

Arduino uses Arduino Programming language that is almost the same as C and C++ programming language. The Zigbee protocol is compatible with arduino which have analog input and digital input and output. Arduino also can integrate with Zigbee for 1 mW to 100 mW power output, 250 kbps RF data rate and frequency of 2.4 GHz, operating at 5 V to 12 V [13].

2.4 CARBON MONOXIDE

Carbon Monoxide (CO) is one of the harmful gases that exist during combustion and can cause severe poisoning accidents. Based on research conducted, intoxication of carbon monoxide is serious and can occur by inhalation of only 0.01% (100mg/m3) of carbon monoxide in ambient air[15]. Carbon monoxide gas is very hard to detect due to its physical properties that are odourless, tasteless and colourless, thus making it even more harmful and dangerous. A special needed for monitoring purposes in order to monitor the surrounding air concentration of carbon monoxide during rescue operation.

History shows that from 1992 to 1996, death case due to carbon monoxide poisoning had been recorded at 14% in construction industry [16]. Prevention is needed in order to prevent more intoxication of carbon monoxide from occurring in the future especially towards fire fighter. Early detection of carbon monoxide poisoning can be figure out with having symptoms like muscle sore, headache, and tiredness during working at affected area. The fumes containing carbon monoxide is fatal even before the person itself realized there is something wrong. Inhalation of carbon monoxide can reduced the amount of oxygen in haemoglobin of red blood cell to drop drastically and replaced with carbon monoxide. The concentration of CO can be measure form 50 ppm in ambient air up to thousands ppm especially in the area where the combustion occurred. Figure 2.5 shows the temperature characteristics of CO and CH_4.

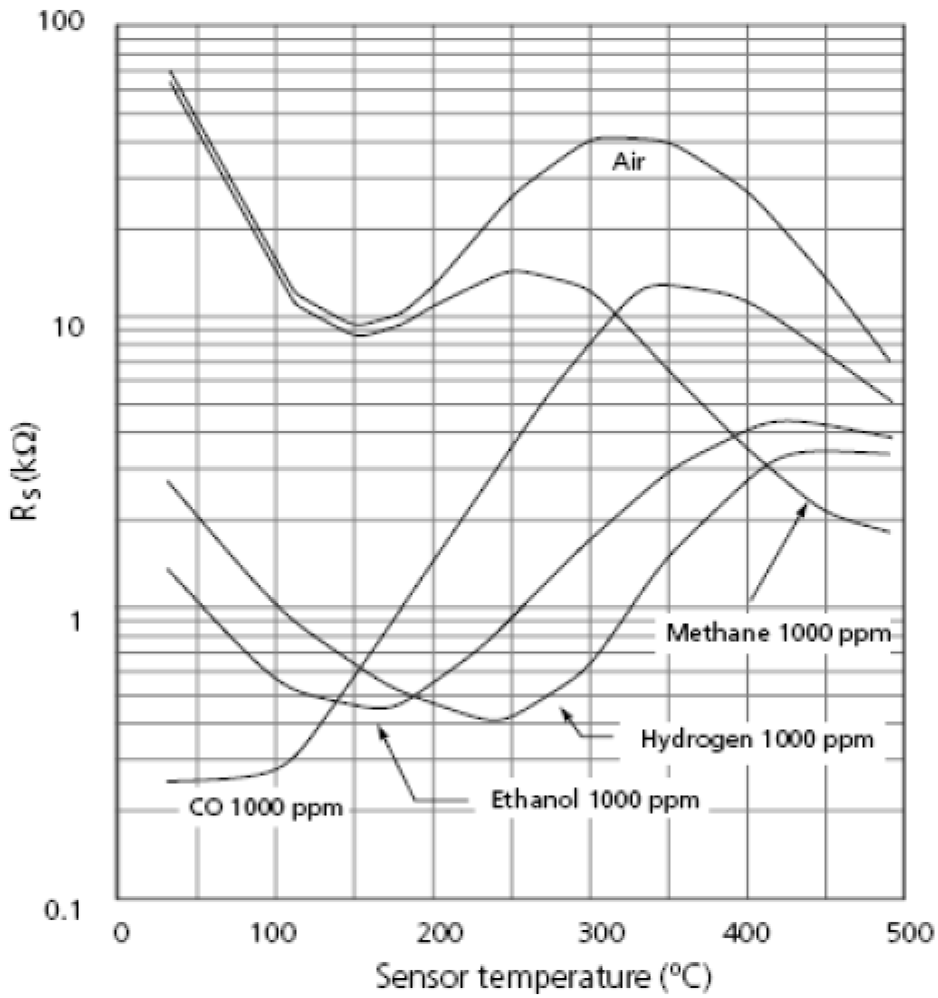

FIGURE 2.5 Temperature Characteristics of CO and CH_4 [15]

Monitoring devices for CO gas had been developed for this purpose. Cordos [15] has developed a device that can monitor carbon monoxide gas and methane gas. SnO_2 was produced that act as the sensor and the gas measurement were done by inducing electric on it while absorbing the gas on the metallic oxide casing. SnO2 sensitivity is determined by the temperature. Methane gas recorded 400°C sensitivity temperature and carbon monoxide gas recorded 90°C sensitivity temperature.

CHAPTER 3

METHODOLOGY

3.1 RESEARCH METHODOLOGY

The research methodology for this project is shown in Figure 3.1.

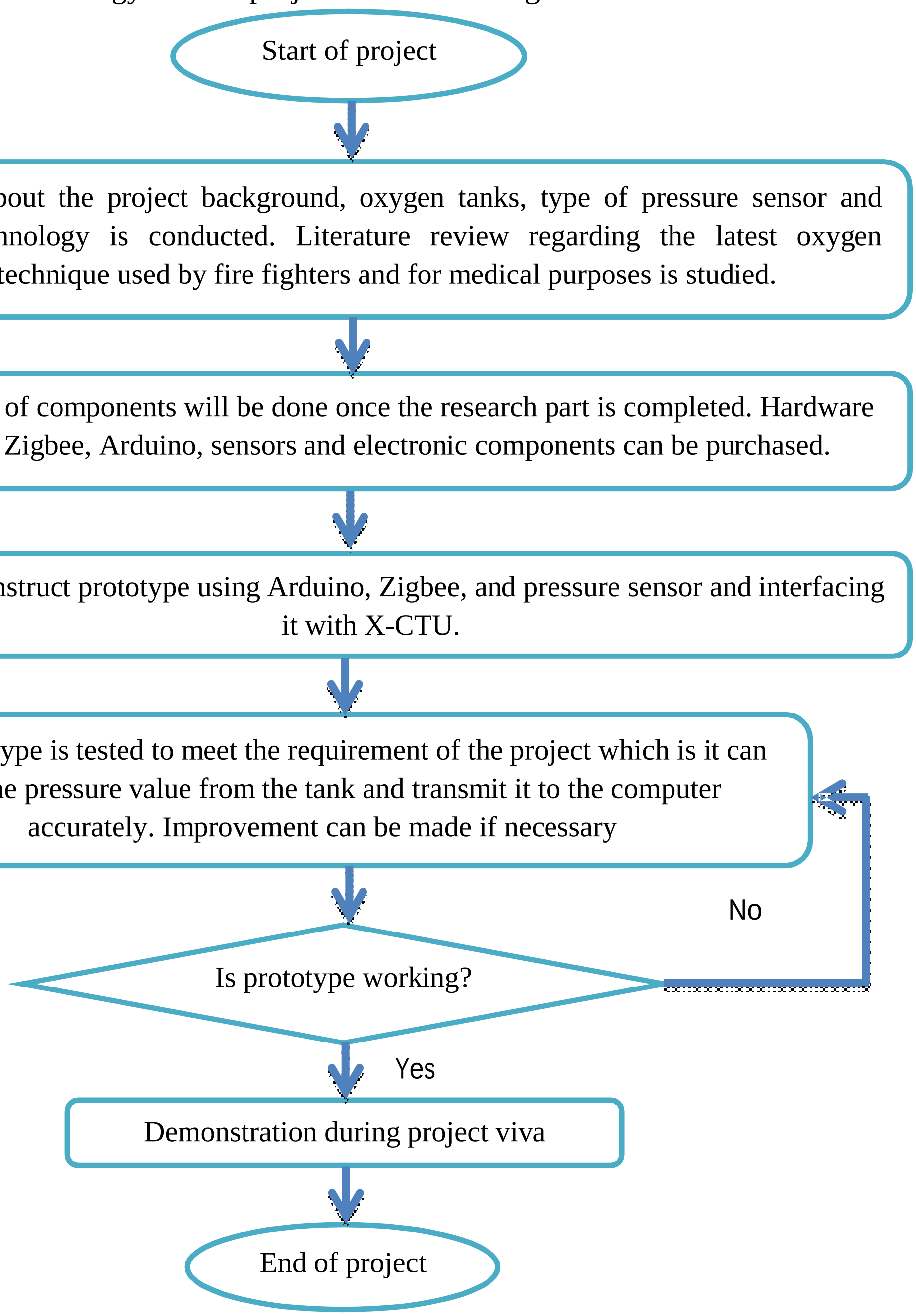

FIGURE 3.1 Project Flow Chart

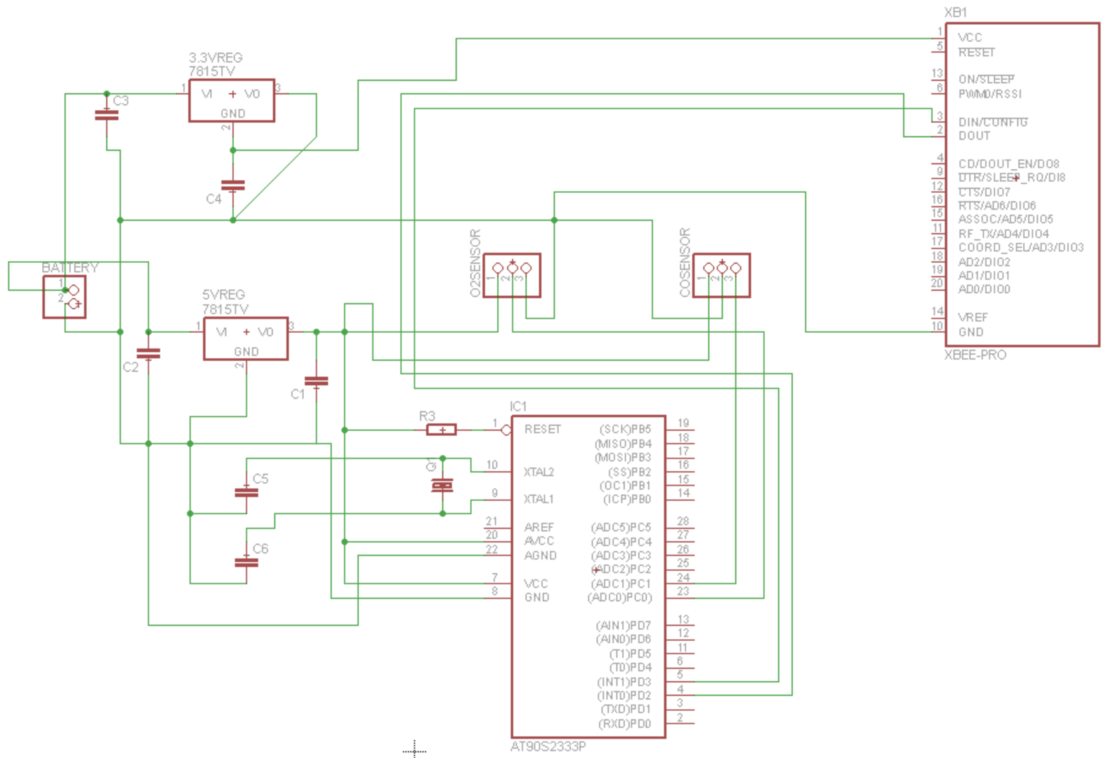

FIGURE 3.2 Project Circuit

Figure 3.2 is the schematic of the project circuit designed using Eagle PCB software. The circuit consist of a supply of 5V for the sensors and microcontroller and the supply of 3.3V is for Xbee Pro. The type of Zigbee module used is the Xbee Pro S1 for both transmitter and receiver. Both of the Xbee modules have been configure to communicate with each other using X-CTU programme. The ATMega328P microcontroller is programme to read the analogue input value for both sensor and send the data to Xbee Pro S1 transmitter to be transmitted to Xbee Pro S1 receiver that is connected to the computer. The Xbee Pro receiver will display the value received from both sensor at the computer screen.

3.2 GANTT CHART

The Gantt chart is the flow of datelines that need to be met in order to achieve the objectives of this project. FYP 1 and FYP 2 have different datelines and activities. The Gantt chart for datelines in FYP 1 is shown in Table 3.1.

TABLE 3.1 Gantt Chart for FYP 1

Activity (FYP 1)	**Week**													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Project Topic selection														
Research work and literature review														
Submission of Extended Proposal														
Proposal Defence														
Prototype work														
Interim Draft Report Submission														
Interim Report Submission														

The Gantt chart for datelines in FYP 2 is shown in Table 3.2.

TABLE 3.2 Gantt chart for FYP 2

Activity (FYP 2)	**Week**													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Develop Prototype														
Data Analysing														
Finalize Prototype														
Pre-SEDEX / Electrex														
Draft Report														
Final Report														
Viva														

3.3 KEY MILESTONES

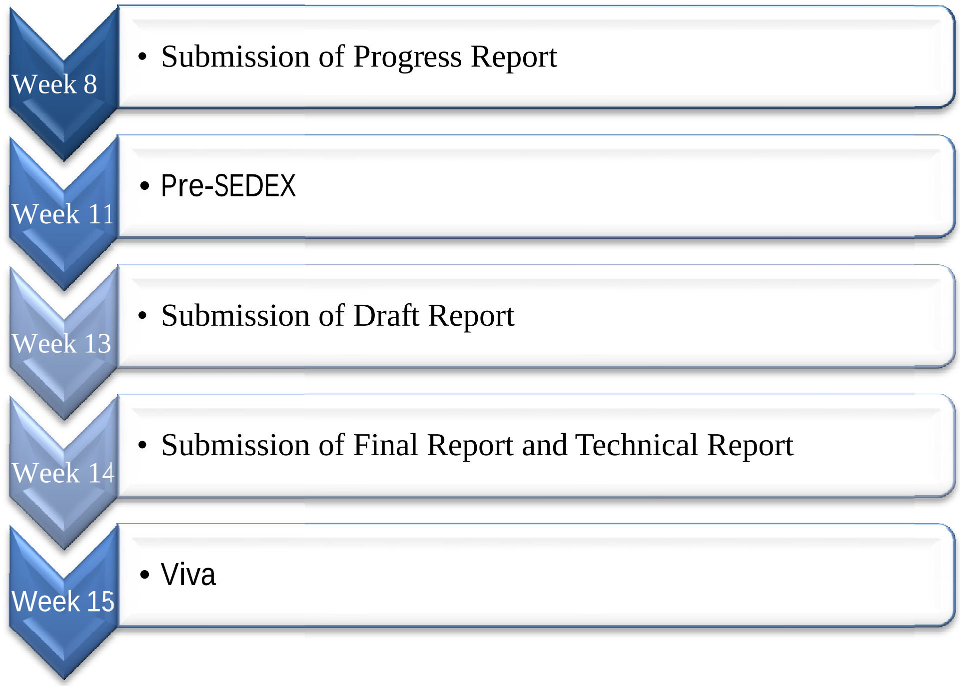

FIGURE 3.3 Key Milestones

Figure 3.3 shows the key milestone of this project that highlights the important dates which is the evaluation dates for the project. The first part of the project is about the submission of progress report to supervisor. The second part of the project milestones is about the presentation that needed to be done during Pre-SEDEX day. The poster presentation will be conducted during week 11 and will be evaluated by a panel of examiners from inside and outside of the university. The third milestones of the project are the submission of draft final report to supervisor. The draft purpose is to identify any mistakes and corrections needed to be done before submitting the final report. Submitting the final report and technical report is the fourth milestones of the project. The reports will be evaluated by internal and external examiners assigned by the department. The final milestones of the project are the viva or presentation day. The viva will be done on week 15 in front of supervisors and external examiners.

3.4 TOOLS AND EQUIPMENTS

3.4.1. Pressure Transducer

Pressure transducer is a type of sensor that measures the pressure of equipment. Pressure transducers are used in most control and instrumentation equipment that needs regular updates on the pressure. In this project, the type of pressure transducer used is the Honeywell PX2AN1XX200PSAAX that can measure pressure up to 200 Psi. The transducer is fully calibrated and has been standardize for the sensitivity, transducer offset and non-linearity. The sensor is operating at 5V voltage supplied from the battery and has full scale span output of 90% Vs, which is around 4.5V and 10% Vs for null output value which is around 0.5V. The sensor configuration uses the Wheatstone bridge configuration which will convert the measured pressure in voltage by applying pressure to the strain gauge which is attached to the diaphragm of the transducer. The diaphragm will produce a deflection force or strain and eventually will produce an electrical resistance charge directly proportional to the pressure [17]. The ratio metric sensor is suitable for this project because it can withstand temperature up to 125°C and also can measure pressure up to 200 Psi.

3.4.2. Carbon Monoxide Sensor MQ-7

The carbon monoxide (CO) sensor is a type of sensor that can measure the concentration of CO gas in the surrounding area. The highly sensitive sensor is made from micro AL_2O_3 ceramic tube, Tin Dioxide (SnO_2), measuring electrode and heater that are soldered onto a stainless steel board. The sensor has a high sensitivity to carbon monoxide which the range of detection is set from 20 ppm to 2000 ppm. The sensor is supplied with two different heating voltage levels, 5V for the high heating voltage and 1.4 V for low heating voltage. The high voltage level heating time must be set for 60 seconds and low voltage heating time is set for 90 seconds. The CO sensor has a preheat time of 48 hours to calibrate the sensor and is suitable to be used for firefighting purposes. Figure 3.4 shows that signal output from the MQ-7 sensor.

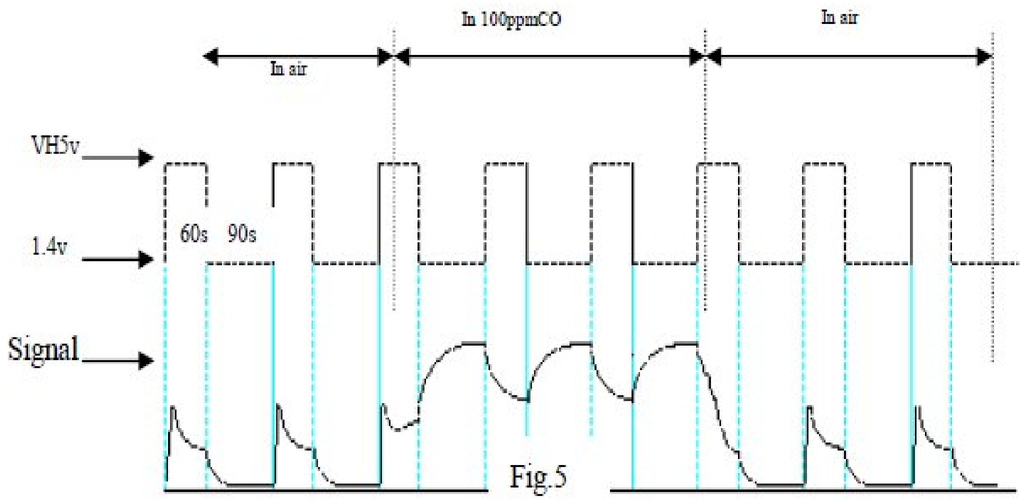

FIGURE 3.4 Signal Output of MQ-7 CO Sensor

3.4.3. Xbee Pro S1

Xbee Pro S1 uses Zigbee technology and it was manufactured by Digi International. Zigbee is a communication protocol registered under IEEE 802.15.4 and Xbee is the microcontroller that uses Zigbee protocol [13]. Zigbee technology is suitable to be used with this project because it has long transmission length compared to Wifi and Bluetooth, low power consumption and also can carry suitable amount of data around 250 kbit/s that are enough for analogue data reading. Both Xbee Pro S1 for transmitter and receiver have been configure in order to communicate with each other only. Zigbee working principle is to send data received to a mesh network set by a router device to reach a further one.

CHAPTER 4

RESULT AND DISCUSSION

4.1 HARDWARE SETUP

The hardware setup for the prototype was done on a PCB board specially designed for the oxygen monitoring system and the carbon monoxide monitoring system. The ATMega328P is mounted on the PCB and act as the main processing core for the system. The pressure transducer and CO sensor is connected to the microprocessor and supplied with 5V of voltage supply. The system is powered up with a 9V battery that can support the whole system including the Xbee Pro S1 transmitter. The Xbee Pro S1 must be powered with a 3.3V voltage supply that can be supplied by the voltage regulator designed on the circuit. Figure 4.1 shows the prototype of this project.

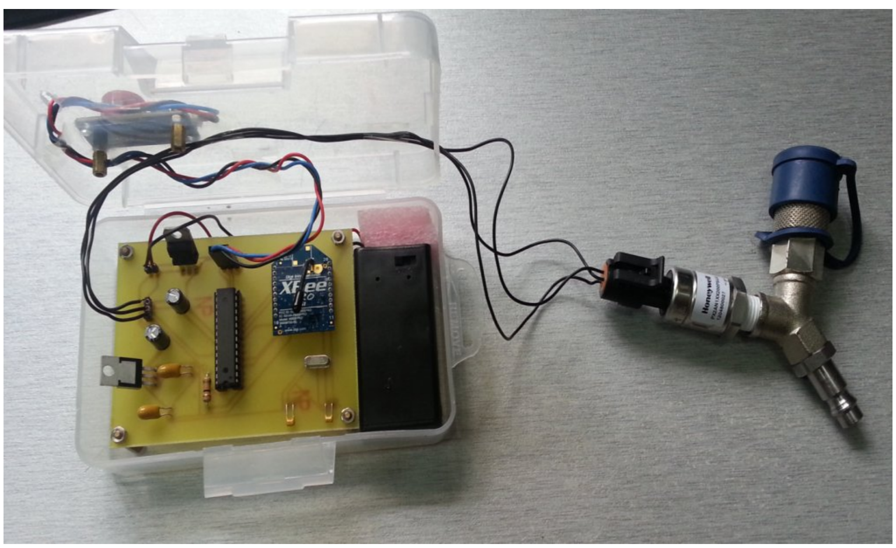

FIGURE 4.1 Prototype of the project

The receiving part of the system consists of a receiver board that connected to the Xbee Pro S1 receiver which called SKXBee. The board will assist the XBee Pro S1 receiver to process the signal conversion between USB and UART signal. The SKXBee will be connected to the computer and the Xbee Pro S1 receiver will be mounted on top of the SKXBee. Red and yellow LED on the board will show the receiving and transmitting process of the XBee and the green LED indicates that the board is supplied with 3.3V voltage. Figure 4.2 shows the SKXBee is connected to the computer.

FIGURE 4.2 SKXBee and XBee Pro S1 Connected to the Computer

4.2 SOFTWARE SETUP

The software used to monitor the data transmitted from the transducer and sensor is the X-CTU provided by Digi International. X-CTU will display the transmitted data in its serial monitor at the monitoring computer where the SKXBee is connected. In order to set the connection between XBee Pro S1 receiver and transmitter, a few steps need to be taken. The X-CTU will display the output from the transducer and the sensor if the SKXBee is connected to the computer. Figure 4.3 shows the COM port used by the SKXBee.

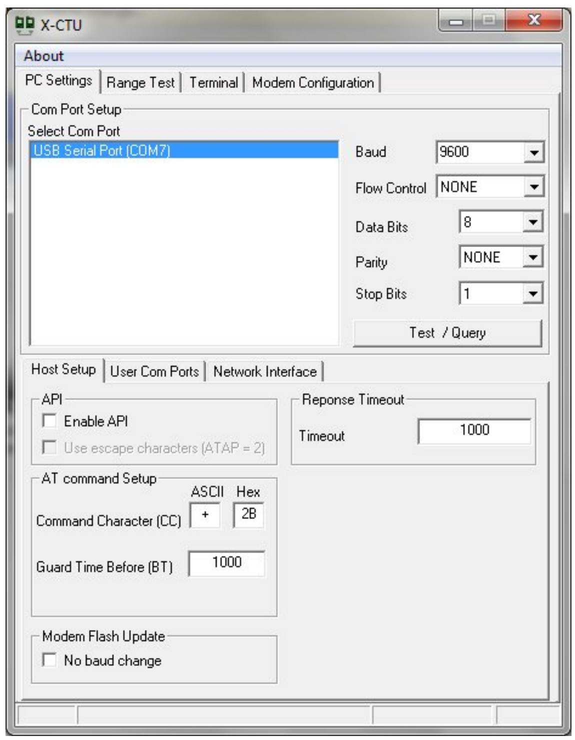

FIGURE 4.3 COM7 is used by the SKXBee

The COM 7 is selected which indicated the port where the SKXBee is connected and the device need to be tested in order to make sure it functions perfectly. Figure 4.4 shows the test process of the XBee modem.

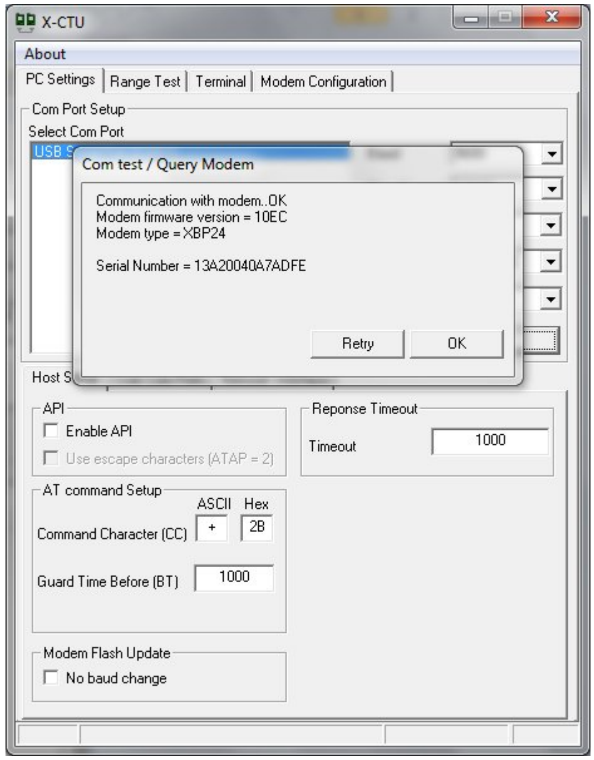

FIGURE 4.4 Com Test for XBee Transmitter

The display will show that the modem is connected and functions perfectly. In order to communicate with the XBee Pro S1 receiver, the modem needs to be assigned an address number for Source Address (MY) and Destination Address Low (DL). The receiver XBee need to have the same but opposite number of DL and MY address and the address can be assigned with any number in the range of 64-bit destination address. The PAN ID for both XBee need to have the same address. Table 4.1 lists out the address for both DL and MY at the receiver and transmitter.

TABLE 4.1 DL and MY Addresses for XBee Receiver and Transmitter

	XBee Pro S1 Receiver	**XBee Pro S1 Transmitter**
DL Address	10	5
MY Address	5	10

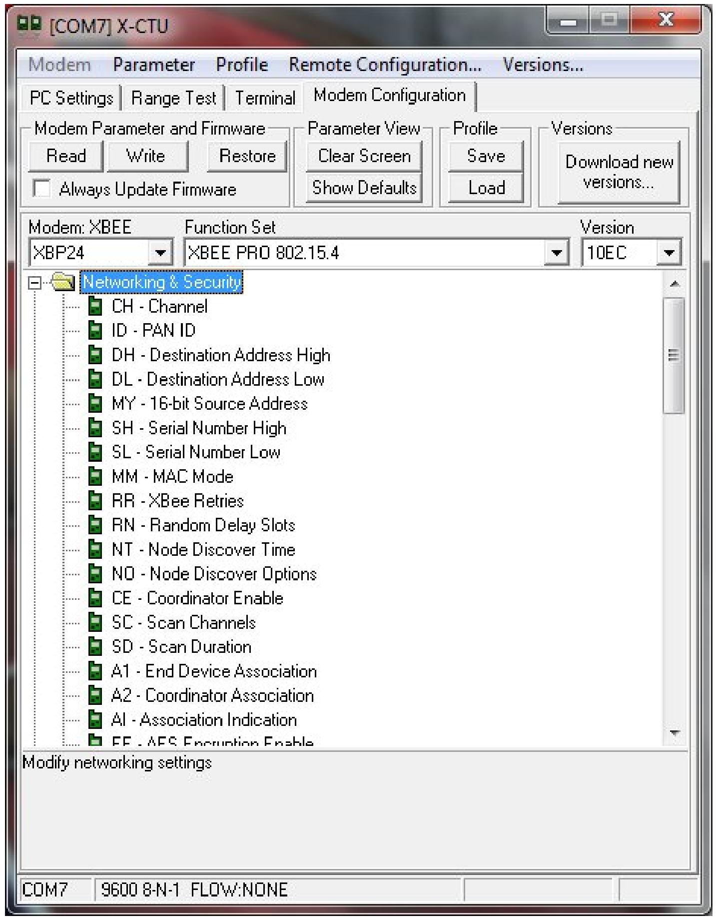

FIGURE 4.5 Network and Security Setting for XBee

Figure 4.5 shows the layout for network and security setting at the X-CTU. Both XBee need to be configured using this method to allow a connection to established between the two modem so that communication can occur. After configuring both transmitter and receiver XBee, the modem is ready to transmit and receive data from the transducer and sensor wirelessly.

4.3 FUNCTIONALITY TEST

4.3.1 Oxygen Tank Pressure

The pressure transducer is connected to the output valve of the oxygen tank in order to get the pressure reading coming out from the tank. The tank pressure is recorded at 170 Bar based on the reading at the gauge meter. Figure 4.6 shows the reading of the pressure inside the tank.

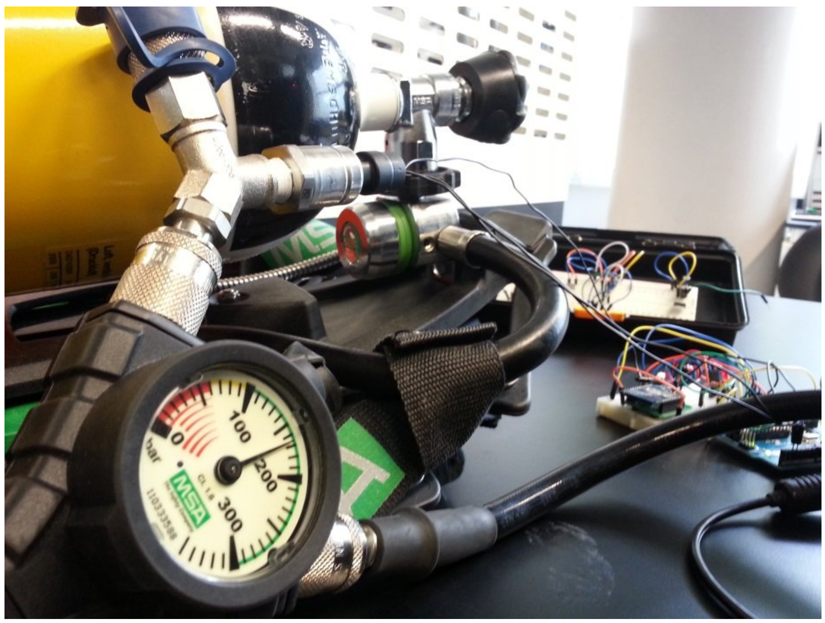

FIGURE 4.6 The Pressure of Oxygen Tank Recorded at 170 Bar

Based on the tests conducted, it shows that for zero pressure applied to the sensor or when the air vent of the tank is closed, the output voltage given is 0.5V and for 200 Bar of pressure applied to the sensor the output voltage recorded is 2.5V. This result is accurate since the type of transducer used is ratio metric pressure transducer. A ratio metric transducer will display the output voltage value based on the supplied voltage to the sensor. Since the output pressure at the input of the sensor is not reaching 200 Bar, the output voltage produced is only around 2.5V.

Based on research conducted, the amount of pressure at the breather mask and sensor section is the same as ambient pressure which is equal to one atmospheric pressure (Atm) or 14.675975 psi. The pressure regulator connected to the sensor and pressure gauge will regulate the amount of pressure coming out of the tank to the breather mask to avoid high pressure at the breather mask. Pressure regulator will regulate the amount of oxygen pressure to a breathable amount of pressure by using a spring attached to the inside valve to control the opening of the valve and will regulate the amount of pressure coming out of the valve [18]. Figure 4.8 shows the display at the serial monitor of Arduino IDE.

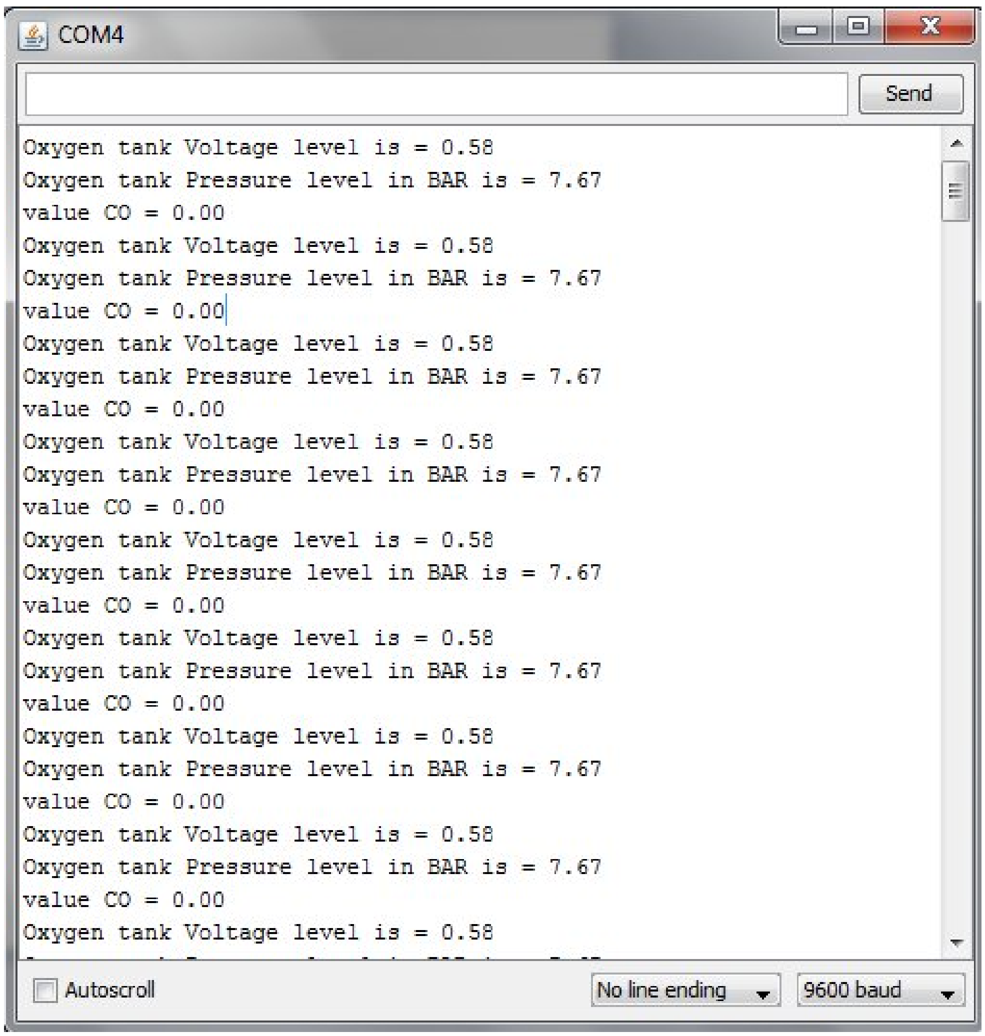

FIGURE 4.7 Serial Monitor for Zero BAR Pressure Result

After receiving output signal due to the pressure, the sensor will send the data to the Arduino board to be processed and display. The serial monitor from the Arduino board will display the voltage value when zero pressure is applied at the sensor and also will display the voltage value when 200 Bar pressure from the tank is applied to the sensor. Since the output voltage is in analogue value, a conversion is needed in order to know the voltage value of a specific pressure. The Analogue-to-Digital conversion (ADC) can be done by calculating the analogue voltage measured using the ADC equation in Eq. (1)

$$\frac{\text{Resolution of ADC}}{\text{System Voltage}} = \frac{\text{Analogue Reading}}{\text{Analogue Voltage mesured}} \quad (1)$$

ADC value varies among microcontroller and since the Arduino board uses a 10-bit ADC for its analogue input, it can read or detect $2^{10} = 1024$ discrete analogue values[19]. Thus, the ADC resolution is set to 1024. The system voltage or the sensor voltage is set to 5V, supplied by the Arduino board. The analogue reading part is the readings obtain from the analogue output sensor, which ranges from 1 – 1024. Therefore, by using the formula, the output voltage of the transducer can be calculated and displayed on the serial monitor. Figure 4.8 shows the result at 200 Bar pressure.

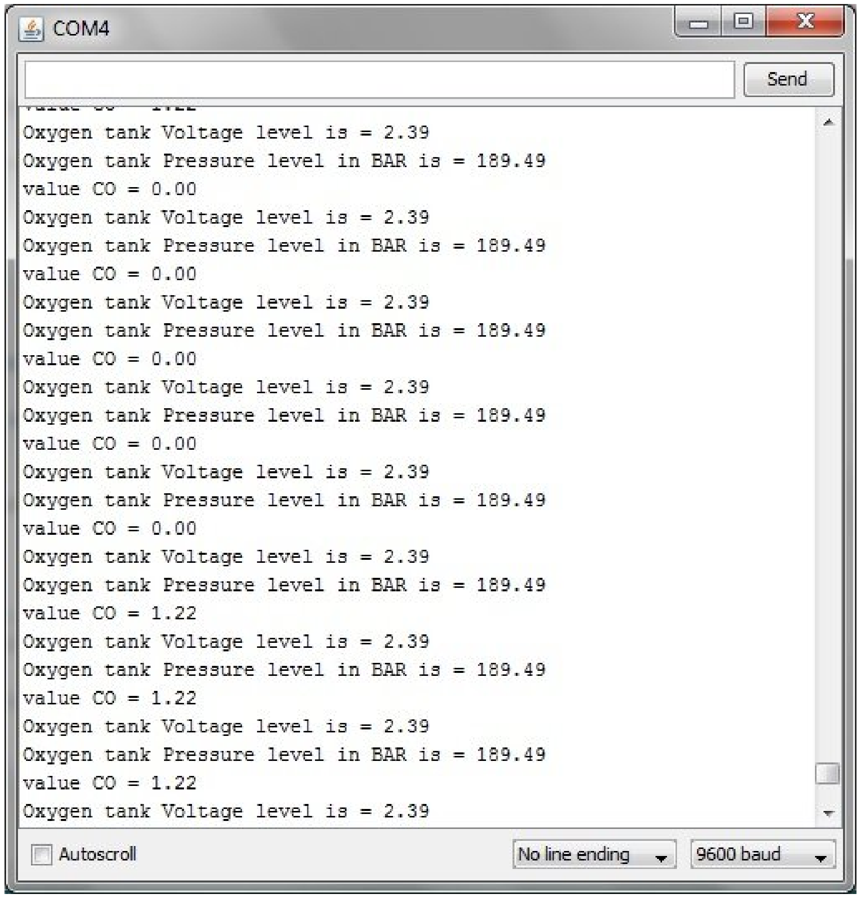

FIGURE 4.8 Serial Monitor for 200 BAR Pressure Result

When the transducer is applied with maximum value of pressure which is 200 Bar, the output voltage recorded is around 2.39 V which also accurate to the original values. The result shown from Arduino serial monitor in Figure 4.8 will run every second in order to give a real-time value of the pressure from the oxygen tank.

Once the data collected by Arduino is processed, it will send the data to Xbee Pro S1 transmitter to be transmit to the receiver. At the receiving part, the Xbee Pro S1 connected at com 7 port will display the data received into the X-CTU serial monitor. Both the transmitter and receiver must have the same address in order to communicate with each other. Figure 4.9 shows the X-CTU serial monitor displaying the result from the sensor and transducer.

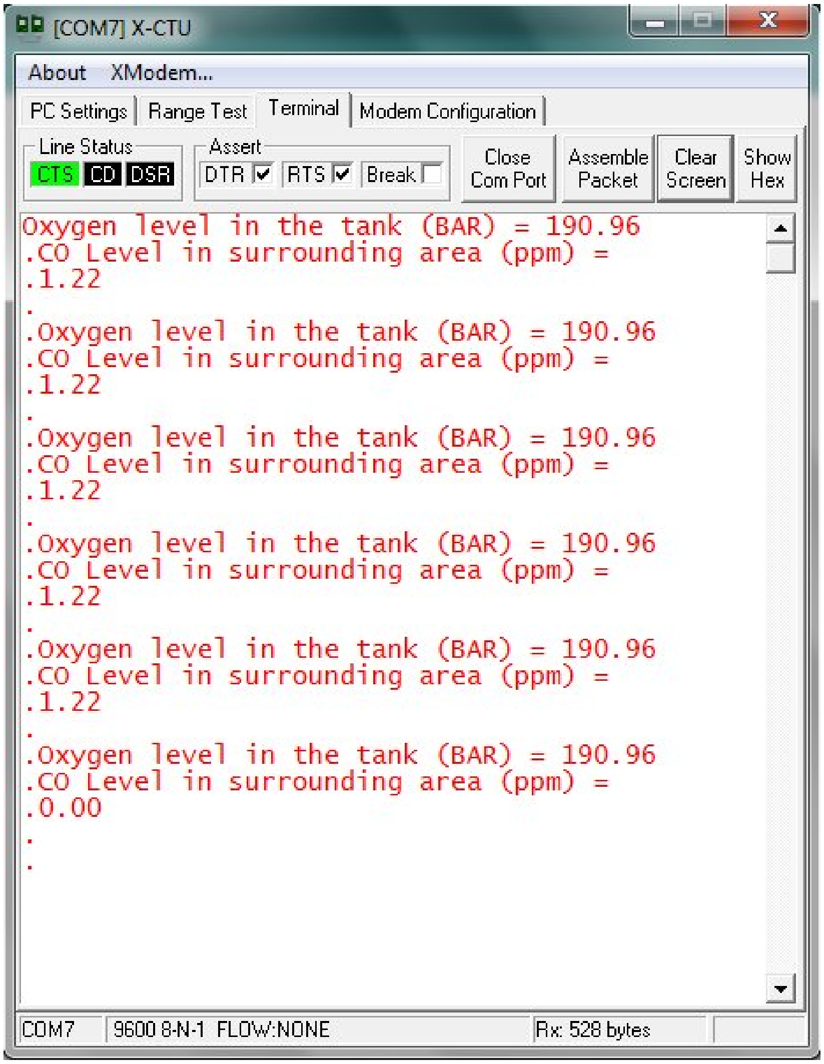

FIGURE 4.9 X-CTU Serial Monitor Displays the Data from the Transducer and Sensor

The X-CTU serial monitor will display the value of pressure converted from received output voltage and also will display the Carbon Monoxide (CO) value collected from the CO sensor. The figure above shows the recorded value for both pressure of oxygen tank and the concentration of CO in surrounding area.

The result can be further enhanced by setting the alarm level for the system when the oxygen is nearly out of oxygen or the pressure inside the tank is less than 80 Bar. The alarm system will be display on the computer screen if this condition occurs.

4.3.2 Carbon Monoxide Detection

The carbon monoxide sensor can detect CO concentration from 20 ppm to 2000 ppm in surrounding air. CO sensor is equipped into this system because to avoid CO poisoning from occurring to the fire fighters in rescuing operations. Fire fighters who conduct rescuing operation in burning plant or building with high fossil fuel material are exposed to a higher risk of getting CO poisoning since fossil fuel contains a higher number of CO. Carbon Monoxide poisoning can occur if the CO concentration inhaled is around 150 ppm and 200 ppm for a period of time The longer the time of exposure of CO gas, the effect towards the body of the fire fighter is more serious.

Therefore, fire fighters are exposed with CO poisoning that may lead to unconsciousness and death if no precautionary action and monitoring are taken. The CO gas inhaled into the lung will be absorbed by the haemoglobin into the blood, replacing oxygen inside the blood. The effect of this exchange is the body will receive less oxygen within a period of time and can cause many complications to the body.

The testing of the CO sensor is done by lighting up a cigarette and the smoke from the cigarette will be collected by the sensor to detect the level of CO in it. A single cigarette has a CO concentration between 20 ppm to 30 ppm which is much higher than the concentration of CO in open air condition. Therefore, the test conducted can see the difference in CO concentration when the CO sensor is exposed with the cigarette smoke for a period of time.

To view the rise in level of CO in air, software called Processing is used to plot the graph of Carbon Monoxide concentration level vs Time. The level of CO is constant in ambient air when there is no smoke or a burning of a fossil fuel around. Figure 23 shows the level of CO in surrounding air when the cigarette is not lighted up.

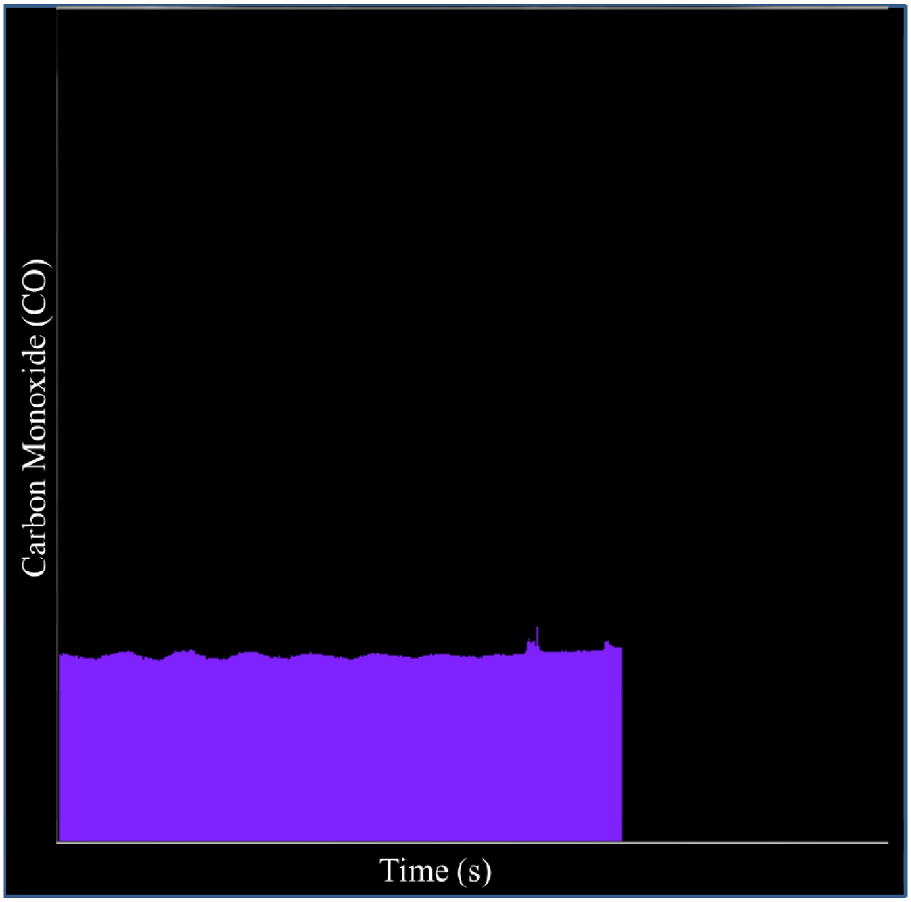

FIGURE 4.10 Graph of CO Level Without Cigarette Smoke

Figure 4.10 shows the graph of CO without cigarette smoke presence. When the cigarette is lighted up and the smoke filled up the surrounding air, the increase in carbon monoxide level can be seen. The graph generated from Processing that there is an increase in carbon monoxide concentration in the surrounding air.

Since the level of CO gas inside the smoke of a burning cigarette is only between 15 to 20 ppm, the level of increment in the graph is not very large. The CO sensor can detect any level of CO ranging from 20 ppm to 2000 ppm in any environment. Figure 4.11 shows the results of CO rise in surrounding air.

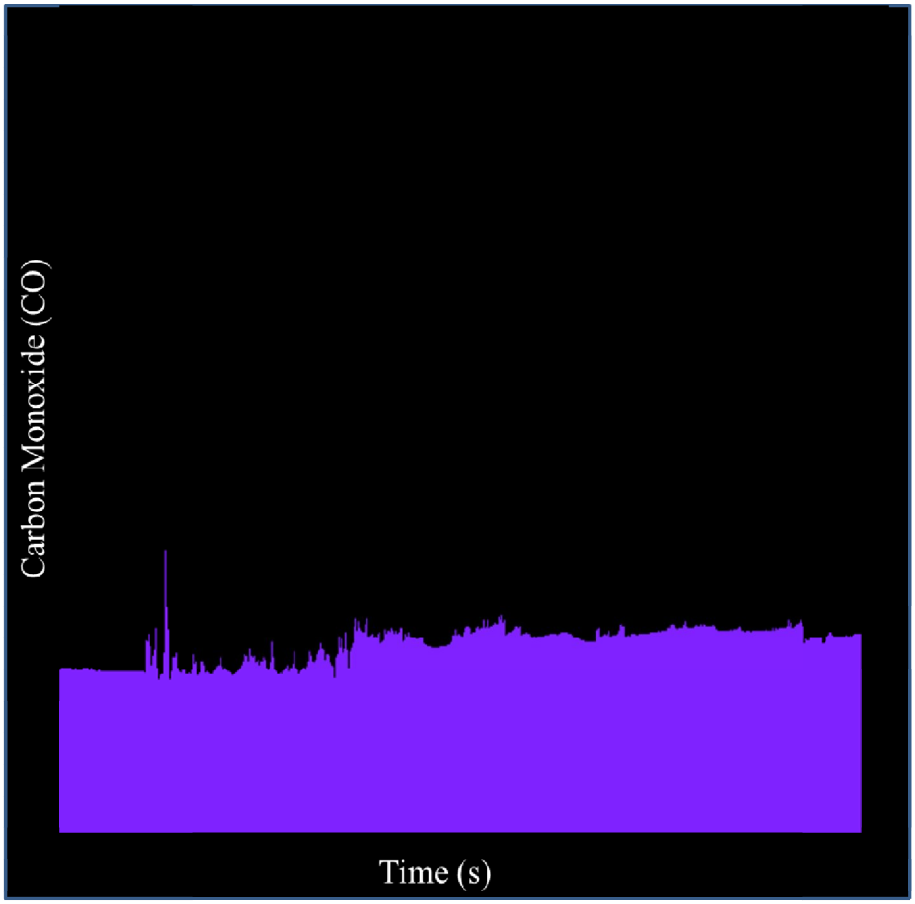

FIGURE 4.11 Graph of CO Level with Cigarette Smoke

Figure 4.11 shows the graph of CO with the presence of cigarette smoke. The result shows the carbon monoxide sensor can detect carbon monoxide gas from a smoke and this will help the fire fighters in operations to know the level of carbon monoxide inside the burning building is high and dangerous if the alarm is displayed on the computer. The system is programme to display a warning sign if the ADC value of the carbon monoxide sensor is more than 700 because this value is high enough for concentration of carbon monoxide in air.

4.4 RANGE TEST

The Xbee Pro S1 module is design to have a specific range of data transmission between the receiver and transmitter. The Xbee Pro S1 modules in this prototype have been tested to see the range of transmission.

There are two type of range tests conducted for the Xbee Pro S1 module which is indoor test and outdoor test. The two types of tests were conducted in order to simulate the real-life scenario when fire fighters are conducted rescue operation in a building or outside of a building. Rescue operations are not necessarily conducted inside a building because it also may involve operation outside a building such as in the forest.

4.4.1 Indoor Test

The test is conducted inside a laboratory and the computer and the receiver module of the Xbee is place at one end of the room. The circuit and the transmitter are set to transmit the reading from a distance increment of 3m. Figure 4.12 shows the reading transmitter by the Xbee can be read perfectly.

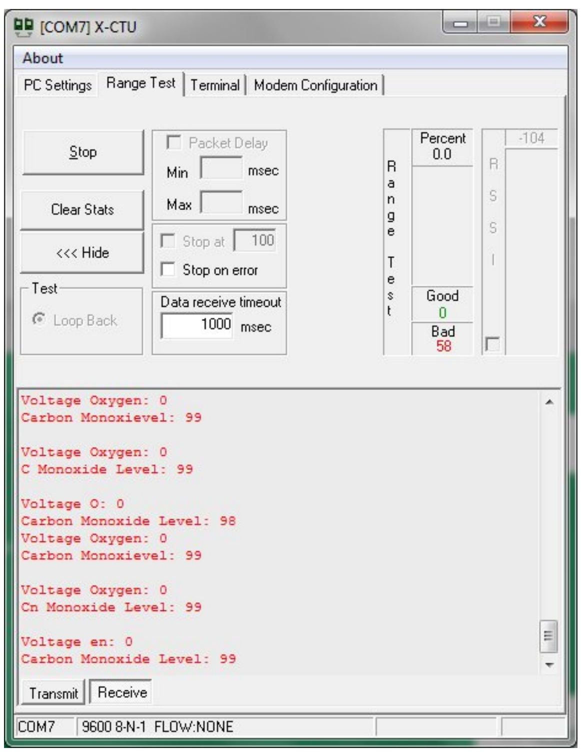

FIGURE 4.12 Range test result less than 10m

After the circuit is moved further away from the computer, the data transmitted begin to show inconsistency and eventually cannot be transmitted. Figure 4.13 shows the result cannot be transmitted by the transmitted at distance of more than 12 m.

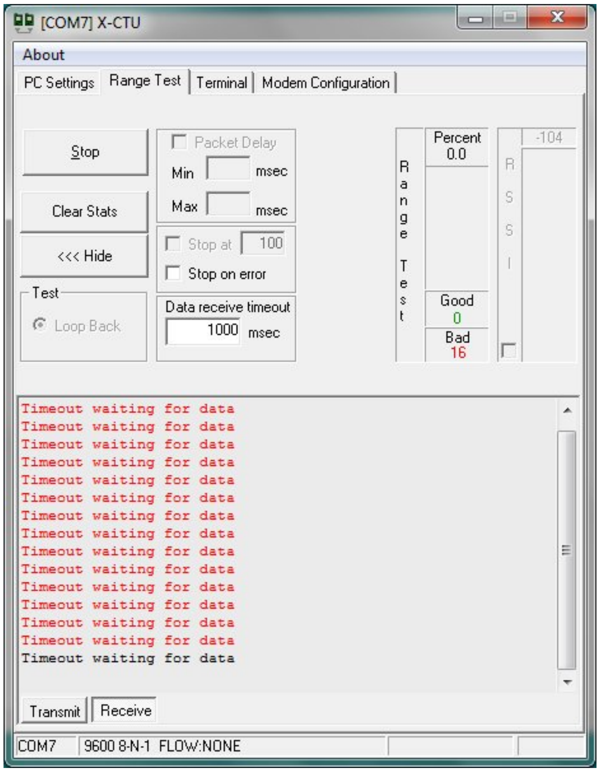

FIGURE 4.13 Range test result more than 12m

The results cannot be transmitted may be due to a lot of interference signal inside the room that prohibit the Xbee transmitter module to transmit the data to the receiver side. The result may have a better reading at better distance if it were tested at different room.

4.4.2 Outdoor Test

The test is conducted on an open space field with less interference signal to interfere with the data transmission. The same method is used in this test where the receiver module and the computer is place at one end and the transmitter module is slowly moved away from the computer.

The transmitter module can transmit the data perfectly for a distance less than 60m. Figure 4.14 shows the result obtained.

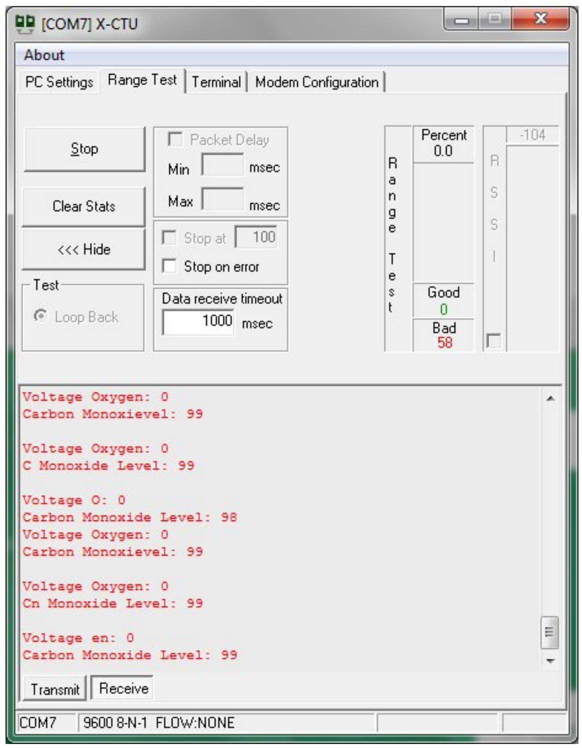

FIGURE 4.14 Range test result less than 60m

After reaching the 60m point, the data transmission strength begins to decrease gradually and eventually lost transmission. This shows that the Xbee Pro S1 have an outdoor transmission data of less than 60m. The result may have a better result if it were tested on a field with less amount of interference signal so that the data can be transmitted perfectly. Figure 4.15 shows the data transmission signal is lost after going further than 60m.

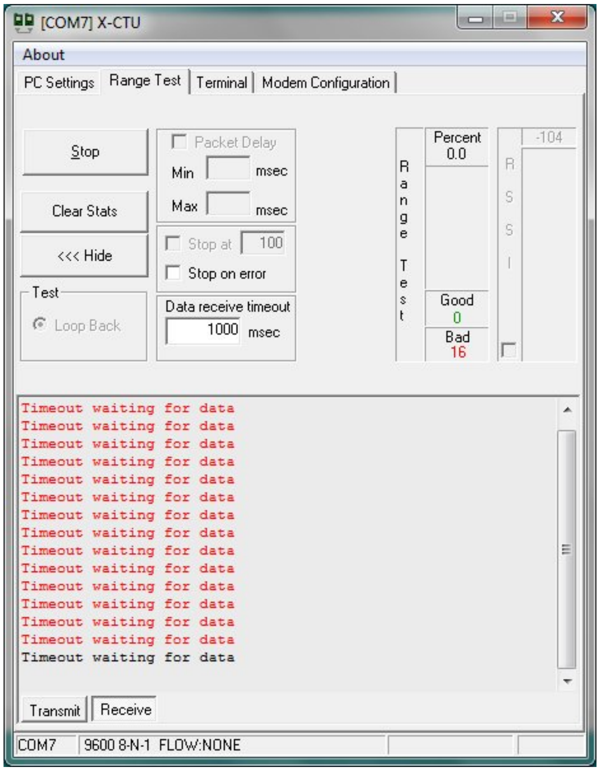

FIGURE 4.15 Range test result less than 60m

The datasheet of Xbee Pro S1 shows that for indoor range test, the data can be transmitted up to 30m while for outdoor range test it can be transmitted up to 100m. This shows that there are large differences between theoretical results and the experimental results. Table 4.3 shows the results obtained for both tests compared with the theoretical result.

Table 4.2 Range test results comparison

Range Tests	Theoretical distance	Experimental Distance	Percentage Difference (%)
Indoor	30m	12m	60%
Outdoor	100m	60m	40%

4.5 COST ANALYSIS

Building the prototype of this project involves purchase of components and tools that are necessary. Table 4.2 shows the list of components and tools purchased to build the prototype.

TABLE 4.3 Items Price for the Prototype

Item	Quantity	Price (RM)	Subtotal (RM)
Honeywell PX2AN1XX200PSAAX	1	80.00	80.00
3 way valve	1	65.00	65.00
XBee Pro S1 modules	2	150.00	300.00
MQ-7 Sensor	1	27.00	27.00
SKXBee	1	54.00	54.00
Transducer connecter	1	86.80	86.80
Arduino Board	1	60.00	60.00
ATMega328P	2	25.00	50.00
TOTAL			722.80

The Honeywell PX2AN1XX200PSAAX transducer and the three-way valve are given by a contractor company that supply the SCBA and fire extinguisher in UTP. The total cost of the prototype is much less than the total cost displayed in the table. XBee Pro S1 is used in this prototype because it is more stable than the other version of Xbee and has a longer range of detection. The MQ-7 sensor is the carbon monoxide sensor that enables the system to read the level of CO in surrounding air. Arduino board and ATMega328P are used to program the transducer and the sensor in order to process the output from both sensor and transducer so that it can be displayed in the computer.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

As a conclusion, this project is beneficial towards the safety of the fire fighters when undergoing an operation such as search and rescue mission. Oxygen monitoring system will prevent the fire fighters from having difficulty to breathe inside a burning area full of smoke because it will notify the user and the third party if the pressure drops below warning level. The prototype constructed managed to maintain the original structure of the tank. From the results it can be seen that the transmission of data from the oxygen tank to the computer using Zigbee will allow smooth data transferring without any disruption as well as a convenient way to use compared to wired transmission data. Data from the oxygen tank and the CO sensor managed to be recorded and transmitted wirelessly using the Zigbee protocol. The project also managed to give a warning if the level of oxygen pressure is low and the level of CO concentration is high. Therefore, the objectives of this project are achieved.

The prototype can be further enhanced in the future by having the permission to modify the design of the oxygen tank in order to add more sensors to collect accurate oxygen pressure readings. A better transmission system such as Wi-fi that has longer transmission range can be used to transmit all the data wirelessly with less interruption.

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