WIRELESS GSM HAZE MONITORING SYSTEM

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Report submitted in partial fulfilment of the requirements
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ABSTRAK

Jerebu adalah satu keadaan di atmosfera yang menghalang penglihatan di kawasan yang terjejas. Malaysia adalah salah sebuah negara yang terpaksa menghadapi kejadian jerebu berulang kali, namun bacaan kualiti udara tidak mudah diaskses oleh penduduk Malaysia. Oleh itu, unit mudah alih dilengkapi dengan sensor dan peranti komunikasi boleh menjadi alternatif untuk memperoleh data. Antara alatan yang terdiri dalam unit adalah alat deria yang boleh mengukur suhu, kelembapan, tahap karbon monoksida dan ketumpatan debu bersama-sama dengan sistem global untuk modul komunikasi mudah alih dan modul frekuensi radio. Oleh begitu, pengguna dapat menerima bacaan melalui Sistem Komunikasi Mudah Alih Global (GSM) untuk Khidmat Pesanan Ringkas (SMS) atau melihatnya dari monitor. Unit ini datang dalam satu set dua, terminal pemantauan dan pusat pemantauan. Semua bacaan sensor akan diperolehi dari terminal pemantauan dan dihantar ke pusat pemantauan mudah alih untuk paparan visual.

ABSTRACT

Haze is a condition in the atmosphere that hinders visibility in an affected area. Malaysia is a recurring country which haze exists and poses a threat to public health. For a country, which is frequented by the occurrence of haze, air quality readings are not easily accessible by the public. Hence, portable units equipped with sensors and communicative devices could be an alternative to acquire the data. With sensory units that can measure temperature, humidity, carbon monoxide level and dust density along with a global system for mobile communication module and radio frequency module, users will be able to receive readings via Global System for Mobile Communications (GSM) for Short Message Service (SMS) or view them from a monitor. This unit comes in a set of two, a monitoring terminal and a monitoring center. All sensor readings will be acquired from the monitoring terminal and be sent to portable monitoring center for a visual display.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND STUDY

From meteorological standpoint, it is an atmospheric phenomenon where a conglomeration of small dry suspended particles in the atmosphere named lithometeor. In layman term, haze is a condition in the atmosphere that hinders visibility in an affected area. Haze typically comprises of dust and smoke particles that causes the scattering of light when sunlight is present. They are usually white in colour in the atmosphere and appear to be yellowish or orange-reddish when against a bright background (cwb, online). Therefore, when haze is unmistakably present in the atmosphere, our horizontal visibility is damped substantially.

Relating to everything that exist in nature, when is in excessive amount, it could conjure a threat to topple the equilibrium of a system. Likewise, as haze looms over our clear sky disproportionately, it accumulates and when air flow is stagnant or restricted, the high density of haze could very well affect our health, respiratory difficulties and impairs visibility. The effects of haze are detrimental and unfavourable for any outdoor activities. To quantify the severity of haze, various government agencies use an easy to comprehend air quality index which measure the concentration of air pollutant in the air. The air quality index is translated from the data acquired via an air monitoring unit installed at a given location along with a particle sensor. Air quality standards are typically classified into different ranges. Each of the range is assigned with a descriptor, colour code and public health advisory.

According a report released by World Health Organisation (WHO) in year 2014, low and middle-income countries around Western Pacific Region and South East Asia were facing countless outdoor air pollution related issue with 2.6 million death cases (WHO, 2014). For if we could remember, the occurrence of haze had become an annual affair for the local communities of South East Asia. The communities in this region are always on high alert for any signs or reports or haze. Ever since the mid of 20th century, records of transboundary haze occurring regularly have become a common event. The most observable root cause of these haze is pertaining to large scale illegal open burning. They are associated with many irresponsible farmers or land owners who operate only with their best interest in mind, neglecting social responsibility via illegal land clearing by opening burning. As some claims that practices such as slash-and-burn are especially rampant in Indonesia. Cases like these caught public attention and on June 1998, the World Meteorological Organization (WMO) conducted a regional workshop relating to transboundary smoke and haze in Southeast Asia as part of its effort to curb widespread air pollution and environment problems around the vicinity (fire.uni-freiburg, 1998). The workshop is to highlight and manage haze episodes which disrupted the tourist industry, public health, agricultural production, civil aviation operations and maritime shipping.

Citizens of the affected countries have no choice but to brace for haze season by limiting their outdoor exposure and wearing a surgical mask during any outdoor interaction. Schools in the capital of Malaysia, Kuala Lumpur and a few states are force to close when the air quality hits hazardous levels (news.asiaone, 2015)

1.2 PROBLEM STATEMENT

Conventionally, on-site haze monitoring station usually required someone to gather and record haze levels in an area. Most of the times, it consumes time, money and manpower to operate the station. Upon erecting the station, either an electric cable would be connected to the station for power and data acquisition or in-charged personnel is needed to check and consolidate the data from time to time. As simple as it may sound, it would be a hassle if the station located on a mountain side or deep in the forest. Thus, having to implement a wireless system with a monitoring terminal and monitoring centre would greatly improve efficiency, where the data could be remotely monitored and analyse in real time.

As responsible and law abiding Malaysian, Malaysians usually receive our air pollution index readings through news media channel or other government regulatory agency. Any signs of spike in haze level in the atmosphere would be notify by the authority. Given the situation, a fair amount of time is needed before the information would be fed to the public. Therefore, when public health is concern, it is of utmost importance that the public are provided with a timely warning and possible forecast through electronic mail such as email, SMS or voice message? In a way, the public could anticipate before the haze hits.

1.3 PROJECT OBJECTIVES

I. To integrate a GSM (global system for mobile communication) module and RF module into the system to enable real time tracking or warning of haze level.

II. To notify or inform subscribers by sending SMS when haze level in a designated area is hazardous.

1.4 PROJECT SCOPE

There are two main parts in this project, which are the hardware section and software section. This current project will only be done on the prospects of using 1 monitoring terminal, a monitoring centre and a GSM supported mobile phone.

The primary limitation of this system is that its solely based on GSM network for data communication and transmission. It would work well when the monitoring terminal and monitoring centre is within the network coverage of the service provider. The monitoring terminal functions as a data sensing terminal where input data are recorded and processed. When haze level approaches hazardous level, a warning message will be relayed out to a set of subscribers via GSM. Furthermore, an additional signal will send data to the monitoring terminal and be further processed and analyse to display graphical data and more relevant readings.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This section is a consolidation of the journals read pertaining to the study that are either directly or indirectly related. By reading and cross-referencing multiple journals, a clearer picture and insightful findings of the study at hand are acquired.

2.2 WIRELESS GSM (GLOBAL SYSTEM FOR MOBILE COMMUNICATION)

The world's first cellular system to specify digital modulation is the Global System for Mobile Communication. It is classified as a second-generation system where it was developed to solve the first-generation network, 1-G fragmentation problem. It was initially introduced in Europe in 1991 and gradually it had been adopted in many Non-European countries (Vikrant Vij, 2010).

Global System for Mobile communications in short, GSM dominate as the world most widely used cell phone technology. Most cell phones operate under a cell phone service carrier's GSM network by communicating with cell phone towers located in the nearby area. Dating back to the year 1982, the Groupe Special Mobile (GSM) was created by the European Conference of Postal and Telecommunications Administrations (CEPT) to serve as a pan-European mobile technology. As an up-to-date report, according GSM Association (GSMA) nearly 80 percent of the world, which is about 3 billion global population uses GSM technology when making wireless calls and sending text messages.

While in the United States, cell phone users can subscribe to either CDMA or GSM based network carriers. In this case, CDMA stands for Code Division Multiple Access is another major radio system used in cell phones. To clarify this issue, CDMA are used by Sprint, Verizon, Virgin Mobile network carrier, while AT&T and T-Mobile uses GSM. Apart from that, the rest of the world uses GSM network.

The services that are provided by GSM could be classified into three main categories, they are telephone service, data services and supplementary services. However, in this project, we would be utilizing General Packet Radio Services to enable communication between devices that is also part of GSM system.

To simply GSM system architecture in Figure 2.1, the system consists of three major subsystems that are virtually connected together with users through network interfaces, which are Base Station Controller (BSC), Base Transceiver Station (BTS), and Mobile Switching (MSC). In GSM network, a Mobile Station (MS) are the portable devices that we are carrying with us every day, better known as a hand phone in layman terms. Two main components of a MS are Subscriber Identity Module (SIM) and a handset. Whereas a BTS and BSC are under Base Station Subsystem, its role is to perform functions ranging from radio resource controlling to digital signal processing. MSC is tasked to perform setting up call, call routing, collecting billing information, paging, echo cancellation and alerting appropriate registers (Vikrant Vij, 2010). Visitor Location Register (VLR), Equipment Identity Register (EIR) and Home Location Register basically identity the location, the user and manage database of the user.

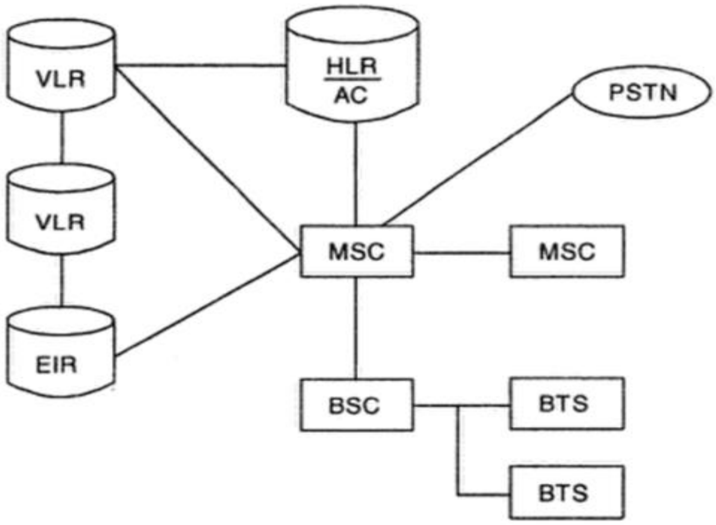


Figure 2.1: Architecture of GSM

Source: Wireless Communication by Vikrant Vij., (2010)

The users of GSM network are identified through a unique SIM (subscriber identity module) card (Gagliarducci, M., Lampasi, D. A., & Podestà, L., 2007). They can utilize the SMS service which falls under GSM function that enable users to transmit to and from a mobile station (MS) text message, containing up to 160 bytes of characters (Peersman, C., Cvetkovic, S., Griffiths, P., & Spear, H., 2000).

GSM network has the advantages of wide covering area, long communication distance mature technology, and sound communication effect and et-cetera (Calcante, A., Tangorra, F. M., Marchesi, G., & Lazzari, M., 2014). As stated by SMS point-point

(SMSPP) standard defined by ETSI (European Telecommunication Standards Institute), this function relies on the nature and of the SMS origin and destination. Whenever a message is send by a mobile station and is terminated, in the absence low connectivity or no connection, a local SMS Center will store it and tries to send it repeatedly for three days as soon as a mobile station is available. Frequency bands in which the GSM network could be operated in Malaysia and most of the world are 900MHz or 1800 MHz (Pereira V., Sousa T., Mendes P., Monteiro E., 2004).

Typically, a GSM module are controlled using industry standard AT command, which is an abbreviation for Attention. Every command line begins with “at” or “AT”, it is a prefix to inform the module the starting line of command. However, they’re also used to control wired dial-up modem. Each of the modem interfaces to the host through a USART (universal synchronous/asynchronous serial receiver-transmitter), that is automatically detected by the operating system. As a clarification, when the term mobile station is mentioned, it refers to the modem. Furthermore, AT commands consist of three parts, starting with AT, then by a command and ended with a line termination character <cr>.

2.2.1 GSM Related-Works

A distribution transformer monitoring system implemented using GSM in (Al-Ali, A. R., Khaliq, A., & Arshad, M., 2004) for the purpose of monitoring and recording key indicators found in a distribution transformer. It is said that, when any abnormality or emergency happen at the transformer, a short message could be send to designated mobile phone to alert whom it may concern. In this research, the parameters measured are load currents, transformer oil and ambient temperatures. Having established that, an embedded system module is designed which consist of a signal conditioning circuit block and controller block. The signal conditioning block is serve to take readings from sensors and convert it to a compatible signal. Whereas the controller block would be in-charge of parameters acquisition, processing, displaying, transmitting and receiving. It is then attach to a GSM modem using a RS-232 data adapter where it could send and receive message of size not more than 160 characters. The time taken to receive an SMS varies from 2-10 seconds depending network traffic.

Chen Peijiang discussed about implementation of a remote monitoring system based on GSM (Peijiang, C., & Xuehua, J., 2008). This system aims to establish remote monitoring platform utilising GSM short message mode. It is stated that this sort of monitoring is most fitting for occasions which has random monitoring scope, small data, difficult wiring and low real-time requirement and so on. Following this implementation, the system consists of a central monitoring station, a GSM network and remote monitoring station. MSP340F149 a 16-bit ultra-low power microcontroller is used as part of the remote monitoring station along with a GSM module TC35 and peripheral circuit. Similar to it, the central monitoring station will also use GSM module TC35 to enable communication between the two station. In addition, Visual Basic 6.0 is the base language that was chosen to develop the control interface, for program initialization of monitoring centre, the program of accepting and sending short messages, data processing and preserving program along with facilitating serial communication. It was also mentioned that GSM network can be interconnected and roamed all over the country.

Looking at a wireless system monitoring point of view, Hui liu proposed a type of wireless sensor network prototype for environmental monitoring in greenhouses that is divided into a two-part framework (Liu, H., Meng, Z., & Cui, S. 2007). Where the first one is allocated for data acquisition with parameters being temperature, soil moisture and humidity, sense by a monitoring network. After that, all the data is redirect to a sink node which it will employ the use of a GSM network to transfer the data to remote management centre. The benefits by doing so comes in lots, it could provide a dynamic real-time data of the landscape on its monitored variables, thus allow scientist to measure properties that had not been previously measured continuously. Similar to our project, the data will be able to be accessed by the terminal through a RS-232 serial interface by the terminal (microcontroller), a single board computer. The terminal is integrated to a few communication ports and its peripheral modules such as GSM module, LCD and touch panel. The system is programmed to perform time-triggered sampling of the sensors for every 5 minutes and programmed to be in sleep state when not sensing or communicating. In addition, the management centre will have a GSM module for receiving data from the monitoring network to be logged in and analyse. It was also stated that RSSI (received signal strength indicator) could be used in such way to examine radio propagation losses caused by misalignment of antenna and its height.

A feasibility study was conducted on application of GSM-SMS technology to field data acquisition (Tseng, C.-L, et al 2006). It is based on field data collection prototype system that composed of field monitoring and host control platforms. Using GSM-SMS based communication architecture to developed a short message format that is used to monitor farming area and record field data, such as humidity, wind speed, number of pest captured and temperature. There are four advantages to mobile communication technology, they are low power requirement, covers a wide range of area, user data can be stored in GSM service centre temporarily and having group broadcast function. Besides that, SMS used in filed data acquisition do not need long cables, contains encryption to protect SMS data and during transmission failure, retransmission can be configured again. Coding and decoding of data between field monitoring and host control platforms can be achieved by predefining data format of SMS. Generally, 160 bytes is the maximum length of a SMS message. As a means to verify the correctness and feasibility of SMS data transmitting across the field, a simple trap device for moth was integrated in the field monitoring platform with a 8051 chip as a counter. Host control platform prototype was create using Visual Basic 6.0 on a PC for the graphical user interface program. The data transmission had a test record of 100% data accuracy rating from performance rating test.

Another study focuses on GSM-based remote wireless automatic monitoring system for field information on case study relating to ecological monitoring of the oriental fruit fly (Jiang, J.-A, et al.2008). In aid of building an accurate and reliable integrated pest management system, information on popular dynamics and related ecological factors can be acquired using modern day wireless communication technology (GSM). Through replaying through traditional monitoring method, cost will be reduced and data collection are more synchronized. By having the population dynamics of the fly over a large scale area, appropriate pest control measures can be taken at the right time and place. Similarly, the system is make-up of 2 parts, which is the remote monitoring platform(RMP) and host control platform(HCP), both with a GSM module to transmit and receive data. To ensure a higher accuracy of the trapping device used here, double counting sensors are used to reduce counting errors of fly. The RMP with its MSP430F449 chip are able to package sensory data and number of trapped flies in a short message and be transmitted to HCP at a pre-set time interval by GSM module. After that, it is written on to MySQL database done in LabView by the HCP for users to access the information. The reliability of this system is concluded to be 95%.

According to Othman, K. A work developing a mobile monitoring system to measure haze level in an area with GSM implementation (Othman, K. A., Abdullah, E. H., Li, N., & Rashid, N. E. A. 2014). GSM modem is one of the application in wireless technology that enable communication between user and the microcontroller system through short-message-system. A MQ-2 smoke sensor reads data which is processed digitally and evaluated before transmitting to receiving mobile phone using GSM modem. MPLAB IDE Version 8 is used for simulation and initial testing to ensure hardware and software are error free. It was highlighted that GSM network is reliable due to its capability on different bands and able to send data to multiple users

A paper by Tang, Z. present a remote alarm monitor and a control system based on GSM and ARM (Tang, Z., Shuai, W., & jun, L. 2011). The system uses a LPC2368 microcontroller, smoke sensor MQ-2, DS18B20 temperature sensor, HS1101 humidity sensor and camera to operate. They are to record any abnormally and send MMS using a GSM module to alert the user. Communication between GSM and the microcontroller is made via RS232 interface. Through testing, the project was a success and whenever abnormality was detected, the system will send an alert message.

As conducted by Gagliarducci, Lamapsi and Podesta on GSM-based monitoring and control of photovoltaic power generation, it is observable that this system is able to record and periodically reports the overall performance of the plant along with in case of anomaly, operators will also be informed immediately (Gagliarducci, M., Lampasi, D. A., & Podestà, L. 2007). Besides that, with appropriate instruction, users are able to modify some working elements of the plants and settings of measurement system. All of this are done under the reliance of GSM network, where the users and the system communicate. The location of where the system is placed are usually difficult to reach and presence of maintenance operators should be low. Thus the reason why the plant had to be monitored and controlled remotely. This motoring and control system (MCS) is a combination of 3 sub-systems, which are the sensor module (photovoltaic sensor cell), data acquisition system (DAS) and the transmission system to and from the MCS using GSM. This system launches three parallel process when it is activated, the first one is to supervise the correct working of the plant and inform the operators when an alarm is set off. The second process records data on the regular functioning of the plant and send an SMS in a timely manner. In the third process, it is dedicated to remotely control and change the measurement settings of the plant after recognition of commands receive by SMS. The changes can be done either through software or activating special switches. As the three process runs concurrently, the shared resources need to be managed, where priority is always given to the third process. Once it is built, the system was tested in a controlled room where long-time verification was done to foresee the working conditions.

A GPS/GSM based birth alarm system for grazing cows by Calcante A. help farmers to act promptly and reduce potential injury to the calf directly cause by the mother or by environmental factors (Calcante, A., Tangorra, F. M., Marchesi, G., & Lazzari, M. 2014). Monitoring calving is important for cows with poor health or with primary labor insufficiencies as well as for cows with valuable off spring. This GPS-Calving Alarm (GPS-CAL) allows farmers to quickly intervene when needed by sending a SMS when delivery begin. In the SMS, birth event data, hour, animal ID and GPS coordinates are stated as well. This particular study is divided into 2 phase, the first phase is to design and develop the GSP-CAL system where hardware selection and firmware implementation, static test to determine horizontal accuracy, precision of GPS and power consumption testing. Whereas the second phase include prototyping under real operating conditions. The GPS-CAL hardware for transceiver and receiver are powered by lithium batteries which could last up to 32 days on regular basis. Upon testing, the system proved to be reliable with 100% sensitivity and 100% positive predictive value.

Another study was done by Hu, J. M on automobile anti-theft system based on GSM and GPS module to notify users of suspicious actions and detect car location (Hu, J. M., Li, J., & Li, G. H., 2012). This system is made up of a GSM module, GPS module, vibration sensor, wireless remote control and MCU unit. Focusing on the GSM module, TC35i by Siemens is selected because it is an integrated module with 900/1800MHZ which support voice and short message.

2.3 SMOKE SENSOR

Smoke sensors are devices that can detect various types of particle in the air, commonly found in smoke detector which in the presence of anomaly would give off an alarm. There are two types of conventional smoke sensor that are typically found, one of which uses an optical smoke sensing unit, where a side of its internal wall will emit light and be received by another side of its wall. Contrary to that, there is also the ionization smoke sensing unit, this concept is similar to an inductor which is able to measure smoke particle smaller than an optical sensor, having cavity in its interior that allows particle to flow through which directly affect the current (Chien, H. C., 2014).

In a simple research done by Ansar Suyuti and her partners on portable gas emission design using microcontroller (Suyuti A., Tola M., Muh. Saleh Pallu, Harun N., Syafaruddin, Takashi Hiyama, 2013). Air pollutant that normally exist in the air are O_2, SO_2, CO, NO_x, SO_4 gaseous and dust particle with heavy metals. Thus smoke sensor with high sensitivity should be implemented to in detecting air pollution or haze. Also mentioned are the types of sensors used in the study, among them are KE25 to detect oxygen, MQ136 for SO_2, MQ7 for CO, TGS2201 for NO_x and MQ2 for opacity of smoke in the air.

Furthermore, research by Abdul Hadi Nograles H. on low cost internet based wireless sensor network for air pollution monitoring using zigbee module, mentioned that MQ2 smoke sensor is able to detect 7 different types of gas compounds and at the same time commercially available (Nograles et al, 2014). This sensor's sensitivity mainly depends on the ratio of sensor resistance (Rs) during expose to smoke and the initial sensor resistance reading, Rs/Ro then being converted to Parts Per Million (PPM) figure using designated equations.

2.3.1 Calibration of Smoke Sensor

Smoke sensors are very handy and useful components to detect the level of certain gas in the air, however proper calibration must be performed to avoid low accuracy and improve the behaviour of the sensor. A brief explanation of the ionization smoke sensor unit, it has a metal oxide semiconductor layer on a substrate of sensing chip together with a heater. When the concentration of a gas in the air fluctuate, the conductivity can be converted to an output signal. Figure 2.2 show the schematic diagram for a metal oxide sensor circuit. One of the way to calibrate a sensor is to have a known concentration of the gas and use it as a reference reading (Hu, K., Sivaraman, V., Luxan, B. G., & Rahman, A., 2016).

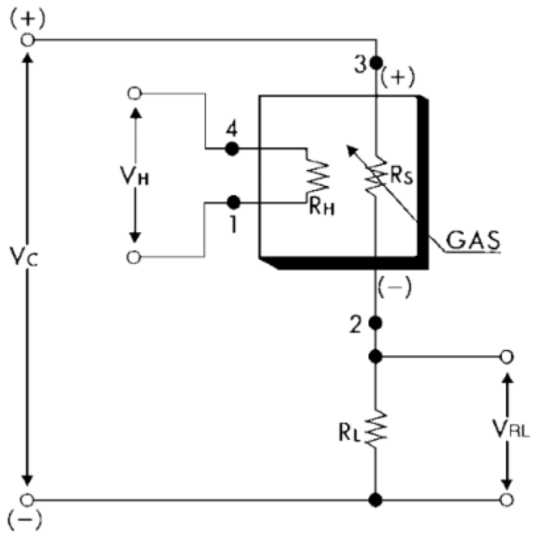


Figure 2.2: Metal Oxide Sensor Circuit

Source: TGS 2602 Datasheet (Online)

A common calibration method would be measuring the output voltage of the sensor by the analogue digital converter, followed by applying the open circuit voltage divider formula below:

$$R_s = \frac{V_c \, X \, R_L}{v_{RL}} - R_L$$

Source: TGS 2602 Datasheet (Online)

Where,

Vc = Input Voltage, normally 5V
v_{RL} = Output Voltage
R_s = Sensor Resistance
R_L = Load Resistance
V_H = Heater Voltage
R_H = Heater Resistance

Load resistance, R_L is usually a resistance value that's is predefined according to specific type of gas. Next, R_0 is to be calculated, it is the value of sensor resistance at a known concentration without the presence of other gases. The calculated R_0 will be used to find the concentration of the gas. Following that, we will then connect the sensor to a microcontroller unit, define the gain and R_L to determine the R_0 resistance at a known concentration.

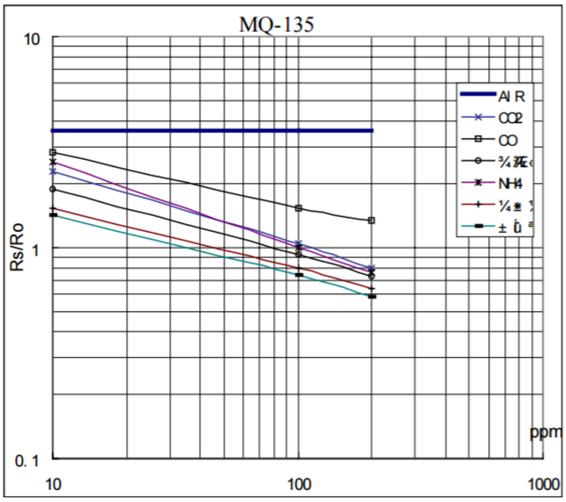


Figure 2.3: Typical Sensitivity Characteristics of MQ-135 for several gas at 20℃, 65% RH, 21% $\boldsymbol{O_2}$ concentration, $\boldsymbol{R_L}$= 20kΩ

Source: MQ-135 Sensor Technical Data

From the log-log plot Figure 2.3,

Ro: sensor resistance at 100ppm of NH3 in the clean air.

Rs: sensor resistance at various concentrations of gases.

Clean Air Factor: R_S/R_O = 3.59

By referring to this value, we are able to calculate R_O of the sensor and calibrate it accordingly.

2.4 ARDUINO

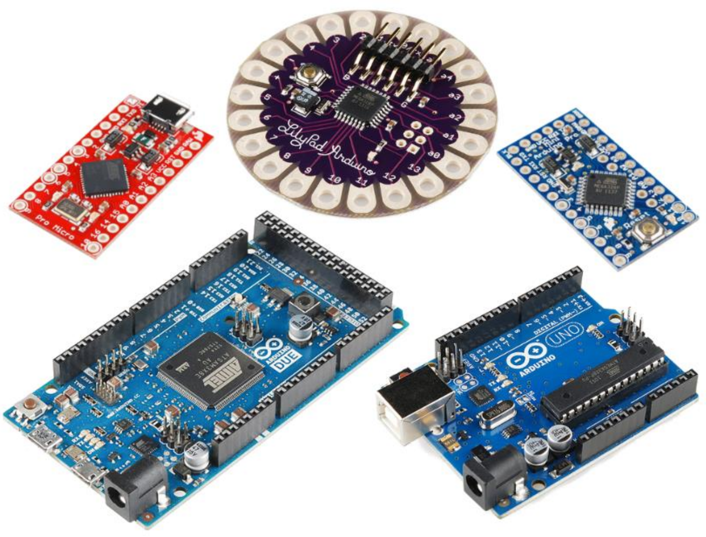


Figure 2.4: Arduino Variants

Source: Online, SparkFun Arduino Comparison Guide, (Online)

Arduino is an open source hardware that was developed to simplify our experience when dealing with microcontroller hardware and software. Arduino was founder by a small group of competent entrepreneur in Italy, they're none other than Massimo Banzi, David Curtilles, Tom Igoe, Gianluca Martino and David Mellis (Arduino, Online). Their goal is to develop a line of microcontrollers which are easy to learn and user-friendly, at the same time having a significant amount of processing power. The penetration of Arduino platform is usually aim at beginners, hobbyists and students who are learning to program a microcontroller for a projects. Even so, Arduino could also be used to run a complex system with adequate knowledge.

Arduino uses a simple programming language derived from C/C++ language in Arduino Software (IDE), to top that up, it a cross platform software where it could run on Windows, Mac OS X and Linux. Arduino products are built to accommodate an open source hardware and software, which translate to openly sharing its development to stimulate fresh ideas among users and further advance its concept (Steven F. Barrett, 2012). Arduino products are program using Arduino Development Environment where interfacing and burning a code into an Arduino is done. One of the product called Arduino Uno is built upon ATmega328 chipset, connecting to a computer via USB port. Another product would the Arduino Mega, slightly bulkier than Uno with added ports is based on Atmega1280 chipset. Sketches are what we use write our program in an Arduino Software which would be later saved in the form of a file extension .ino. Table 2.1 below is a comparison of specifications between Arduino Uno and Mega:

Table 2.1: Comparison Between Arduino Uno, Arduino Mega and Arduino Nano

Source: Arduino, (Online)

NAME	Arduino UNO	Arduino Mega	Arduino Nano
Processor	ATMega328P	ATMega2560	ATMega328P
CPU Speed	16MHz	16MHz	16MHz
Analog In/Out	6/0	16/0	8/0
Digital In/Out	14/6	54/15	14/6
EEPROM (kB)	1	4	1
SRAM (kB)	2	8	2
Flash (kB)	32	256	32
UART	1	4	1

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter emphasizes on the methods used to develop a wireless based haze monitoring system. This mainly involve establishing different systems block and how it interfaced with each other. A brief explanation of each block and its components are described.

3.2 PROJECT FLOW CHART

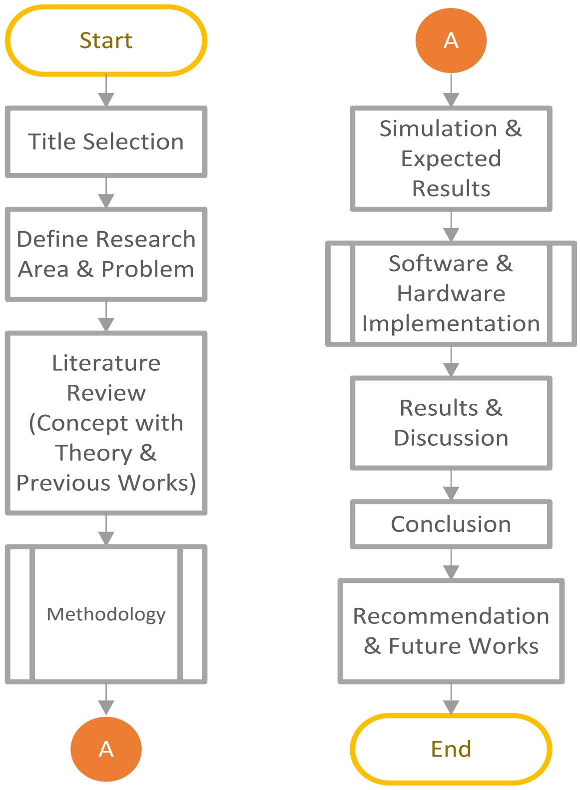


Figure 3.1: Shows the flow chart of the project

Figure 3.1 presents the flow chart for the entire project, it began by defining research areas and problems after a title was selected. Once that is done, various journals relating to similar concept with theory and previous works are studied. Upon gathering enough information, a project methodology is created which then act as a reference for our simulation and expected results phase. After that, the software part and the hardware part are implemented, which would then be used to obtain results and make discussion. Lastly, a conclusion will be written along with recommendation for future works.

Methodology Flow Chart

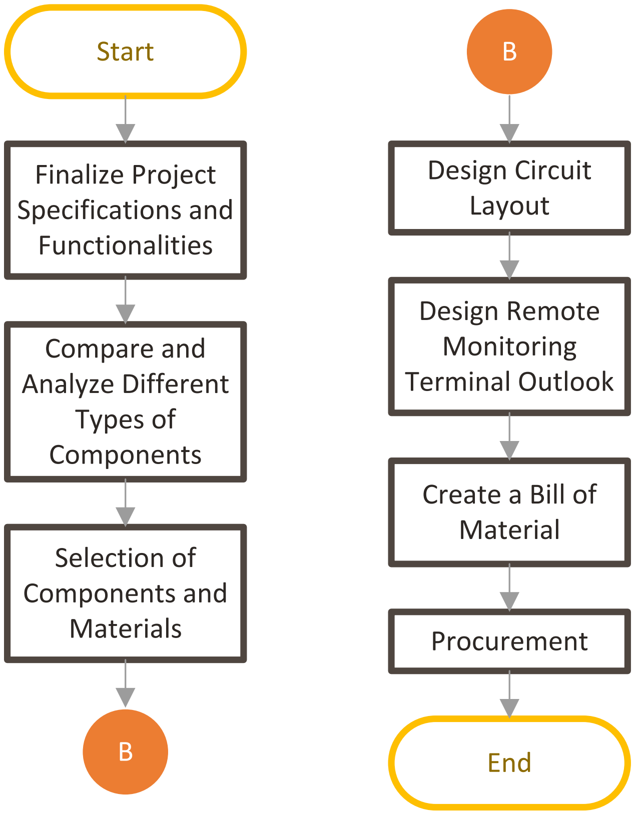


Figure 3.2: Shows the flow chart of the methodology

In Figure 3.2, the chart further explains the methodology that is being adopted in this project. The process is done in an ascending order. The first process would be to determine the project specifications and functionalities. After knowing that, comparison of different types of components is done and be selected. Followed by designing a circuit layout and its exterior outlooks with dimensions. Lastly, create a bill of material and make procurement.

Software and Hardware Implementation Flowchart

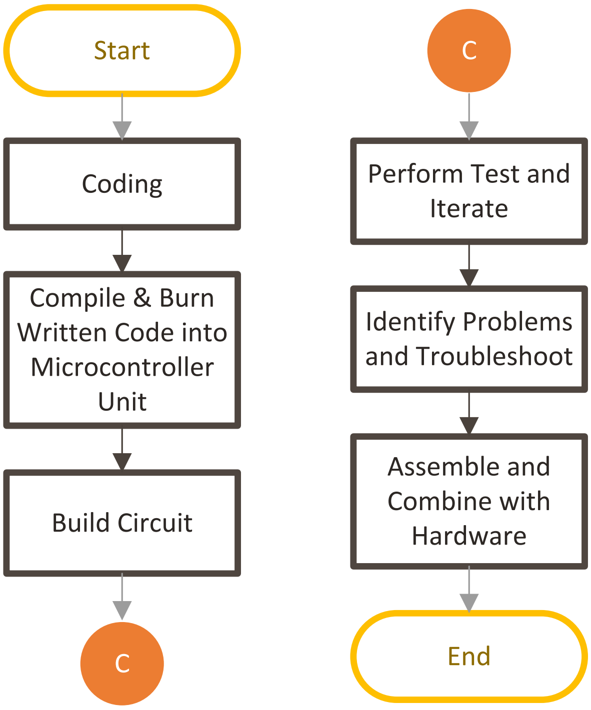
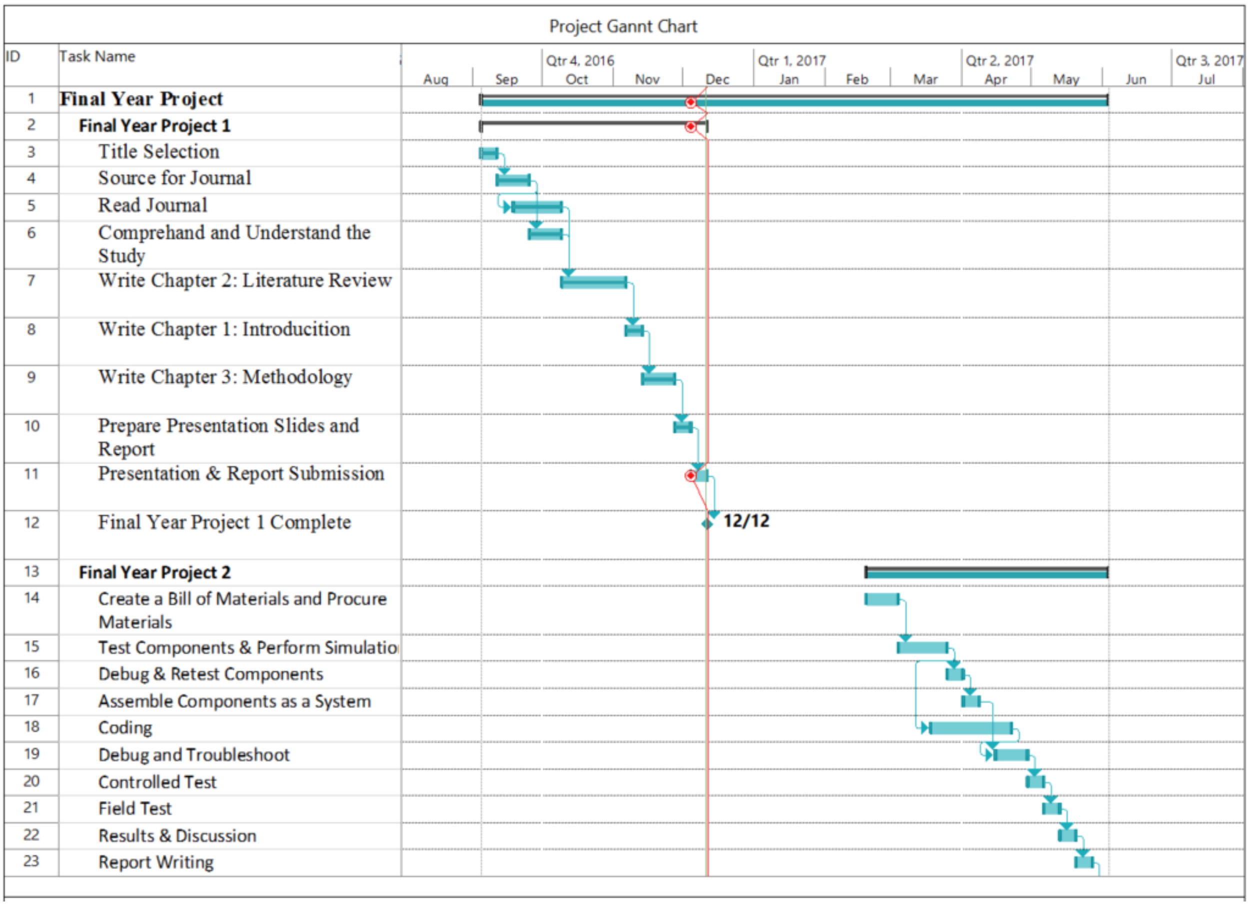


Figure 3.3: Shows the flow chart of the Software and Hardware Implementation Procedures

In the above Figure 3.3 depicts a more detailed flow chart of software and hardware implementation presented in Figure 3.1.

3.3 PROJECT GANNT CHART

Table 3.1 Shows the Gannt Chart for The Project



3.4 BLOCK DIAGRAM OF THE SYSTEM

Haze Monitoring Terminal

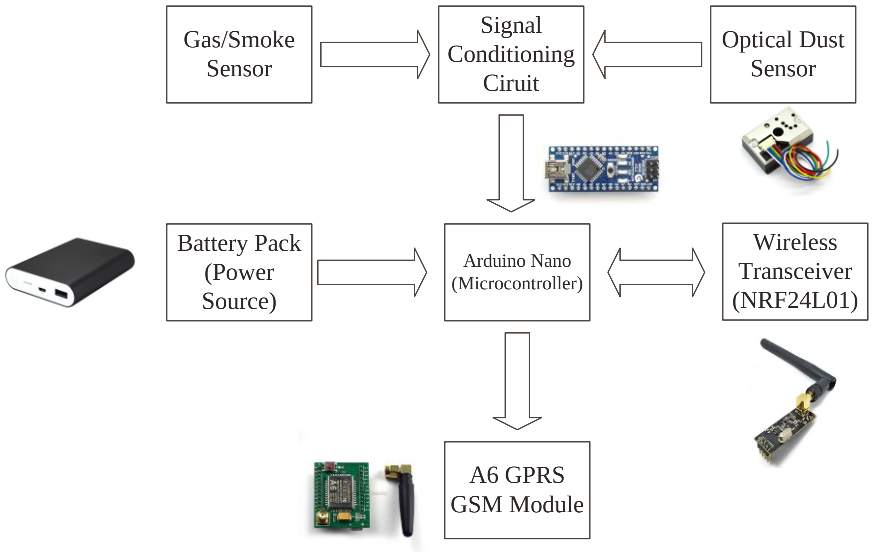


Figure 3.4: Shows the block diagram of the haze monitoring terminal

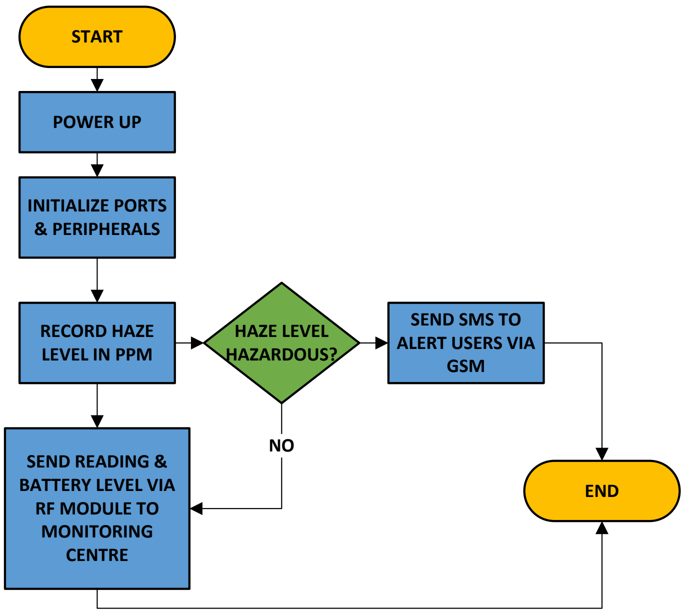


Figure 3.5: Shows the flow chart of the haze monitoring terminal

Haze Monitoring Centre

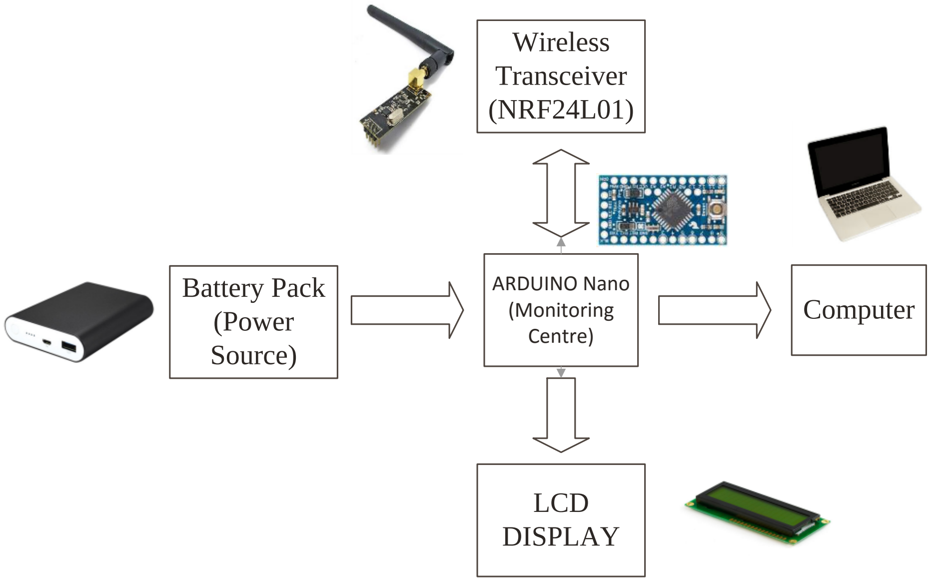


Figure 3.6: Shows the block diagram of the haze monitoring centre

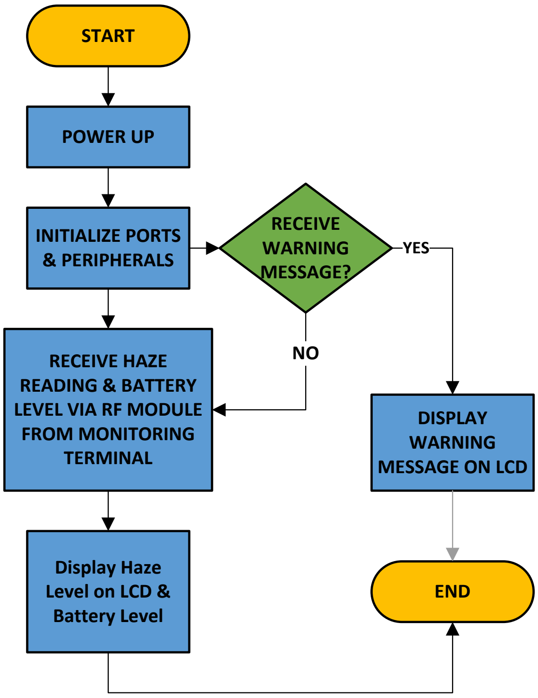


Figure 3.7: Shows the flow chart for the haze monitoring centre

3.5 HARDWARE

3.5.1 MQ-135 Smoker Sensor

Figure 3.8: MQ-135 Smoke Sensor

Source: Circuitstoday , (Online)

According to the datasheet, this sensor is highly sensitive to NH_3, NO_x, alcohol, Benzene, smoke, CO_2 and CO. It is suitable for various application such as gas detecting gas leakage in home or industry use. Besides that, we will be using this sensor to detect CO in the presence of air and to measure the saturation level. Table 3.2 shown below is the technical specification of the sensor:

Table 3.2 Technical Data of MQ-135 Smoke Sensor

Model. No	MQ-135
Sensor Type	Semiconductor
Detection Gas	Combustible Gas and Smoke
Concentration	10 – 110ppm
Operating Temperature	-20°C to +50°C
Operating Voltage	5V
Load Resistance	Adjustable
Sensing Resistance	30KΩ to 200 KΩ

3.5.2 Arduino Uno

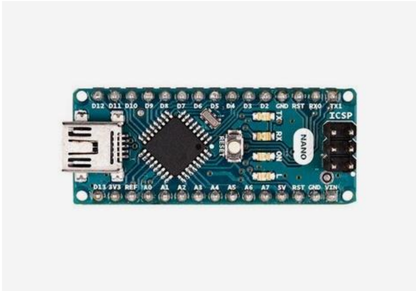


Figure 3.9: **Arduino Nano**

Source: Arduino, (Online)

Arduino Uno will be selected and used as the core of the data acquisition system. It would receive data from the sensor, analyse the data and later on transmit a signal to the haze monitoring centre. Arduino Nano is chosen because it has a library build on top of it with a simplified programming platform. In addition, the operating voltage for this microcontroller is 5V, which coincide with the operating voltage of their other components in this project.

3.5.3 GPRS GSM Module A6

Figure 3.10: A6 GSM Module

Source: picclick, (Online)

There are many readymade GSM modules on the market, which could be bought and use by everyone. To name a few of a quad band embedded products that support GSM are SIM800, SIM900, GT-100, GTM-201 and A7 chips, which could function on all four GSM frequencies. In this project, A6 chip will be used among other GSM modems. It is manufactured by AL Thinker from China which is cheap in comparison to other modules while retaining its features.

The general parameters of this module are shown below in Table 3,3:

Table 3.3: General Parameters of A6 Chip

Source: Electrodragon, (Online)

Parameters	
A6 Chip Dimension	22.8 x 16.8 x 2.5mm
Operating Temperature	-30°C to +80°C
Operating Voltage	3.3V – 4.2V
Sensitivity	<-105
GPRS Class	10
Support SMS	

Support Voice Calls
Standby average current less than 3ma
Support Standard GSM 07.07, 07.05 AT commands
Support GPRS data traffic
Support 2 serial ports

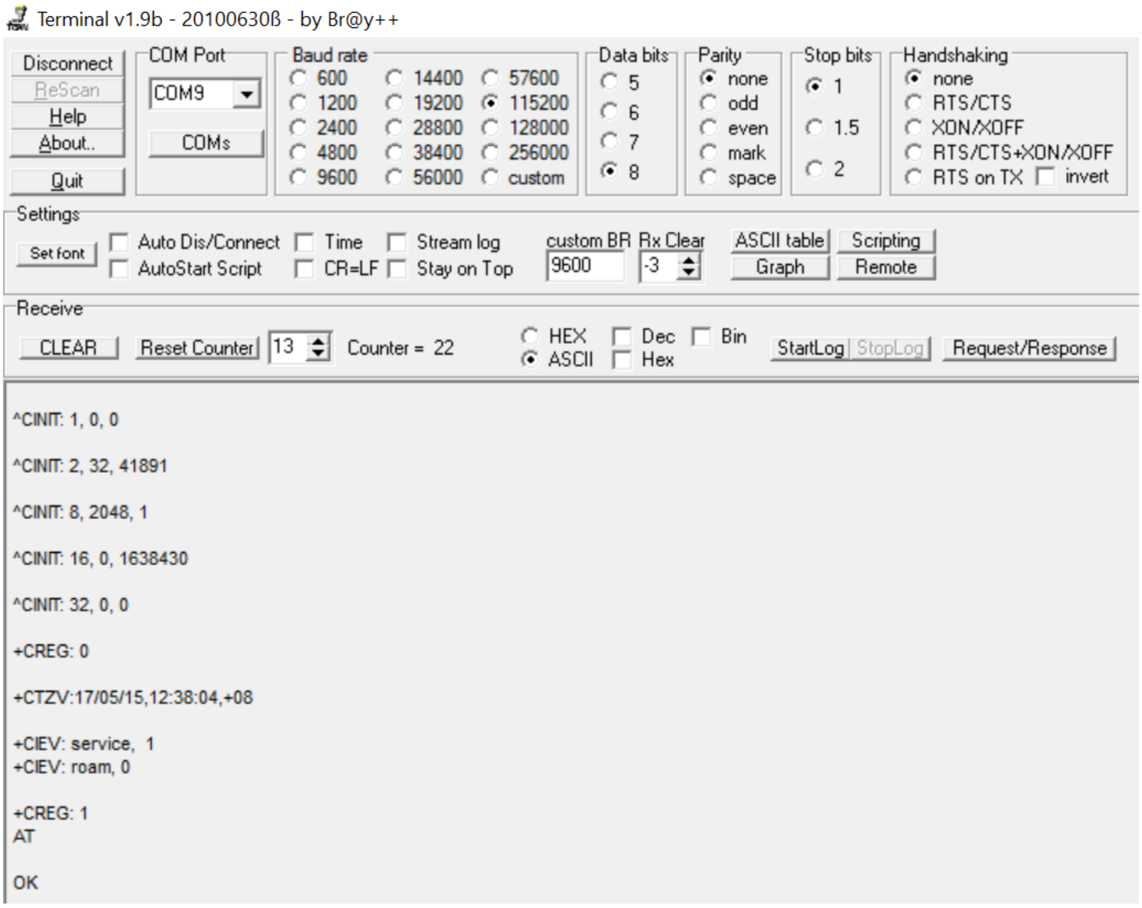


Figure 3.11: A6 GSM Being Initialised by AT Command

The above Figure 3.11 portrays AT command is still widely used to control a GSM module to activate and operate it. Various AT commands could be sent via a serial port to communicate with the device. Hence, a study of AT commands would be needed.

3.5.4 Optical Dust Sensor GP2Y1010AUF

Figure 3.12: Optical Dust Sensor GP2Y1010AUF
Source: Itead, (Online)

This dust sensor uses an infrared emitting diode(IRED) and a phototransistor which is arranged diagonally to detects the reflected light of dust in air. It is especially useful in detecting fine particle such as smoke. It has a low current consumption at 20mA and is 46.0 x 30.0 x 17.6 mm in dimension.

Table 3.4: Parameters of GP2Y1010AUF Dust Sensor

Recommended Parameter	Value
Supply Voltage, Vcc (V)	5 ± 0.5
Input Terminal Voltage,	-0.3 to Vcc
Current Consumption(mA)	11 to 20

From Table 3.4, the working parameters of the dust sensor are listed. It will be referred when necessary and during establishing connection to the microcontroller used. The recommended supply voltage of this sensor is 5V $\pm$0.5V with current draw between the range of 11mA to 20mA.

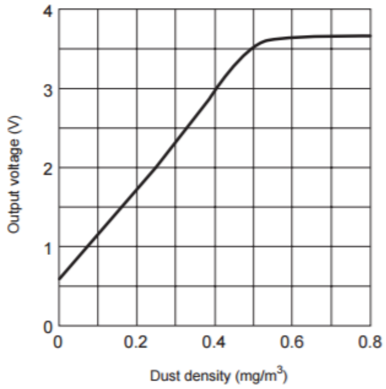


Figure 3.13: Output Voltage Versus Dust Density

Source: Sparksfun, (Online)

On the other hand, Figure 3.12 shows response graph of this sensor in term of dust density (mg/m^3) to amount of output voltage emitted. The trend in this graph shows a linear proportional response from the start till it reaches a saturation limit and remains the same. Hence, it would be easy to operate this sensor without much mathematical model.

Table 3.5: General Health Effects and Cautionary Statements Within Each API Categories

Source: A Guide to Air Pollutant Index in Malaysia by Department of Environment Malaysia

Air Pollution Index (API)	Description
0 - 50	Good
51 – 100	Moderate
101 – 200	Unhealthy
201 – 300	Very Unhealthy
>300	Hazardous

The above table is a general guideline to safe air quality corresponding to API that is being adhered in by the Malaysia's department of environment. For a better understanding, air quality is categorized into five different levels with the ideal being good and least desirable being hazardous. Hence, the project will be based on this reference to translate air readings from ppm to API.

3.6 SOFTWARE

3.6.1 Arduino Software (IDE)

This software is used to preload or program an Arduino. Besides that, it has its standalone cross platform user interface. Version 1.6.13 will be used to program the board for this project.

3.6.2 Visual Studio 2015

Visual Studio 2015 will be used to make a graphical user interface implementing C# to present, record, tabulate and save data from the haze monitoring terminals. This serve as a handy add-on to the project for better data presentation and analysis.

3.7 BILL OF MATERIALS

Table 3.6: Shows the bill of material of the project

No.	Main Components	Price	Quantity	Cost	Remarks
1	Arduinon Nano 3.0	MYR 39.90	2	MYR 79.80	gie.com.my
2	A6 GSM GPRS Module	MYR 16.30	1	MYR 16.30	aliexpress.com
3	MQ-135 Smoke Sensor	MYR 9.00	1	MYR 9.00	lelong.com.my
4	Nordic NRF24L01 Module	MYR 19.10	2	MYR 38.20	mydruino.com
5	DHT-22 Temperature Humidity Sensor	MYR 22.90	1	MYR 22.90	lelong.com.my
6	16X2 LCD	MYR 11.30	1	MYR 11.30	gie.com.my
7	Resistor (set)	MYR 0.30	1	MYR 0.30	lelong.com.my
8	Battery (12 units)	MYR 14.30	1	MYR 14.30	lelong.com.my
9	Battery Holder with Switch	MYR 6.00	2	MYR 12.00	lelong.com.my
10	Single Core Wire	MYR 26.80	1	MYR 26.80	gie.com.my
11	PCB Board	MYR 5.00	2	MYR 10.00	lelong.com.my
12	Optical Dust Sensor GP2Y1010AUF	MYR 28.80	1	MYR 28.80	lelong.com.my
13	Toggle Switch	MYR 2.00	2	MYR 4.00	lelong.com.my
14	5V Mini Fan	MYR 4.00	1	MYR 4.00	aliexpress.com
15	Weatherproof Electrical Junction Box	MYR 15.00	2	MYR 30.00	lelong.com.my
16	Shipping Fees			MYR 41.50	postal
	Total			MYR 349.20	

Table 3.6 depicts the total amount of budget that had been allocated for the procurement of the necessary components at RM 349.2. The quantity and source of procurement are listed out in the above table.

3.8 EXPECTED OUTCOME

This project expects the user to be able to monitor the haze level from a distance not less than 100m away through the monitoring center and be alerted with a SMS at a fixed time interval.

In addition, when haze level exceeds preset level, a SMS alert will be delivered to mobile subscribers to provide a warning, indicating haze category.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter consists of the data that had been collected upon experimenting on the output values of the haze monitor after it is built. A couple of test are performed to measure and record the data for further analysis.

4.2 HARDWARE IMPLEMENTATION

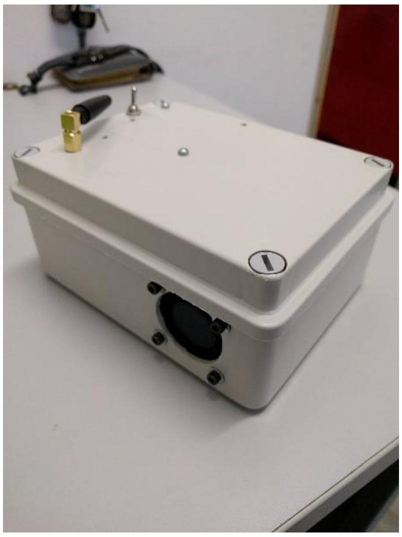



Figure 4.1 and Figur 4.2: Haze Monitorng Terminal Front and Back View

Figure 4.1 and Figure 4.2 are the final design outlook of the haze terminal which will be placed outside to measure and convey out haze readings. Attaached on the boxis a antenna for the A6 GSM module together with a toggle On/Off switch next to it. In Figure 4.1, a small 5V mini fan is attached to the box as an intake point of the surrounding air to the dust sensor inside. Next in Figure 4.2, MQ-135 gas sensor and DHT-22 temperature humidity sensor are protruding out from the box’s surface to measure data.

Figure 4.3: Haze Monitoring Centre

As seen in Figure 4.3, two buttons and a 16X2 LCD display are located on the front side of this box. Alongside that, an antenna and a toggle switch are placed on the top side with a USB cable to its right. The size of each boxes is 120.0 x 155.0 x 70.0 mm in dimension respectively, which makes it easy to carry around and move.

4.3 SOFTWARE IMPLEMENTATION

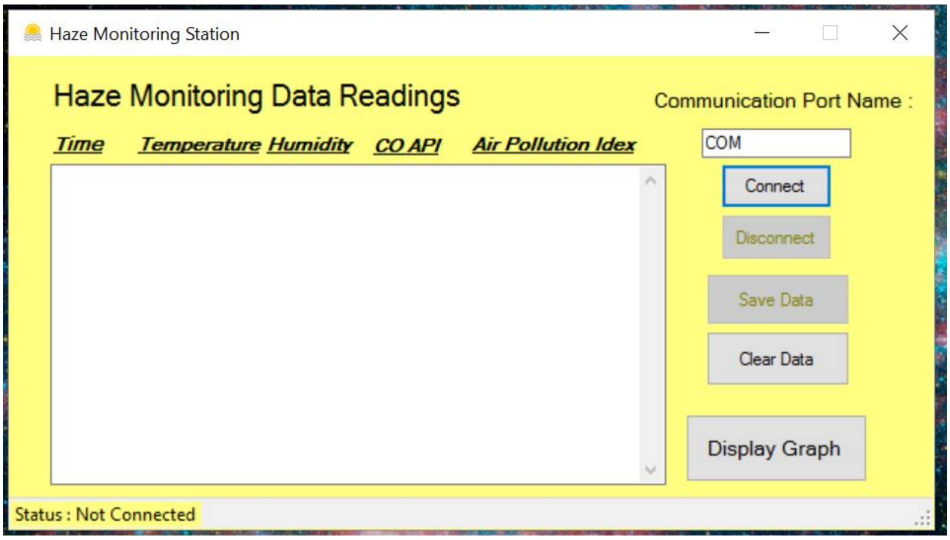


Figure 4.4: Graphical User Interface for Data Monitoring

Shown in Figure 4.4 above is a blank GUI when it is not connected to the monitoring centre. The interface is user friendly and easy to use even for first timers. On it, users will be able to flick through sensor readings at different times. To initialize the program, users will need to connect the monitoring centre to the computer via USB cable for data to appear.

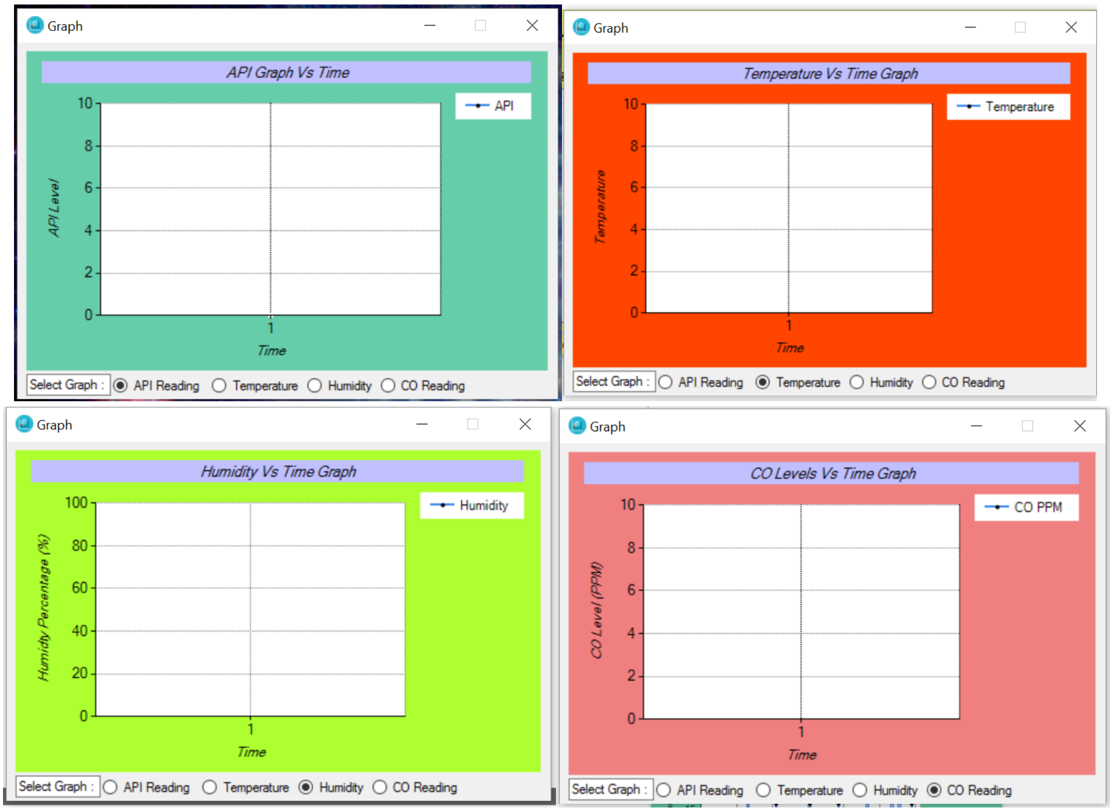


Figure 4.5: Graphical Plot Outlook of Sensor Readings

From Figure 4.5, it shows the outlook of graphical data of the sensor readings after its recorded over time. The readings will be graph in coloured separated form to distinguish different input data.

4.4 Test Phase

4.4.1 PRELIMINARY TEST 1

4.4.1.1 DATA FROM MONITORING CENTRE

The first test run after both hardware and software implementation was completed. The first test was conducted on 14/04/2017

UMP Pekan KK512 from 1512 hour to 1712 hour.

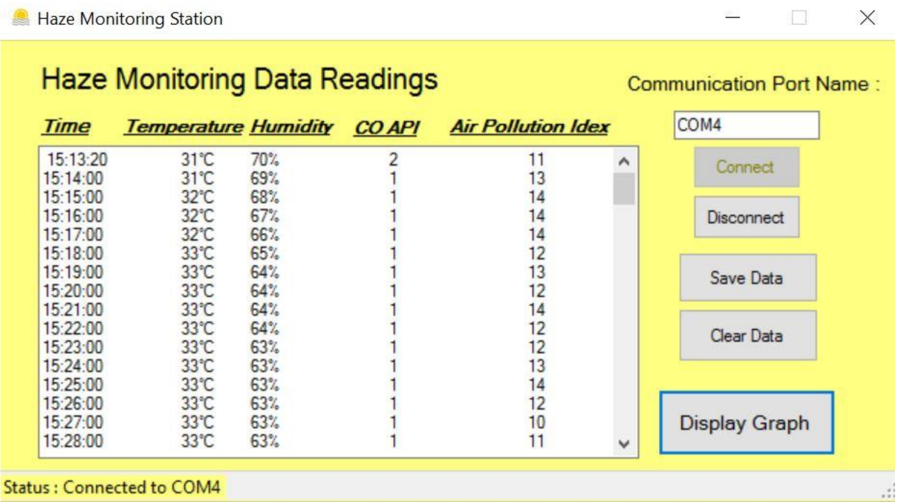


Figure 4.6: Data Acquired Displayed on GUI

It can be observed in Figure 4.6 that the first data was displayed on the GUI at 1513 hour and constantly be updated on a minute by minute basis. The data is presented in an orderly and organised fashion which is easy to read.

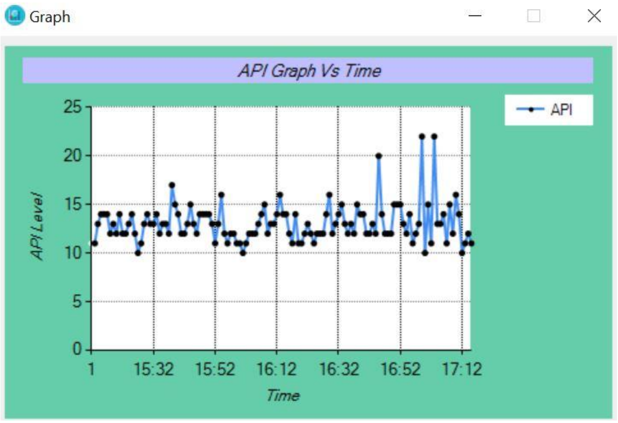


Figure 4.7: Air API Reading Graph

From Figure 4.7, throughout the 2 hours during the preliminary testing, the API level of UMP Pekan fall within the range of 10 to 22. The readings are mostly populated in between 10 and 15. Whilst it is true and relatable, since UMP Pekan is an academic institution with hostels, the air pollution index wouldn’t possible be high under normal circumstances. The readings on this graph is measure using optical dust sensor GP2Y1010AUF.

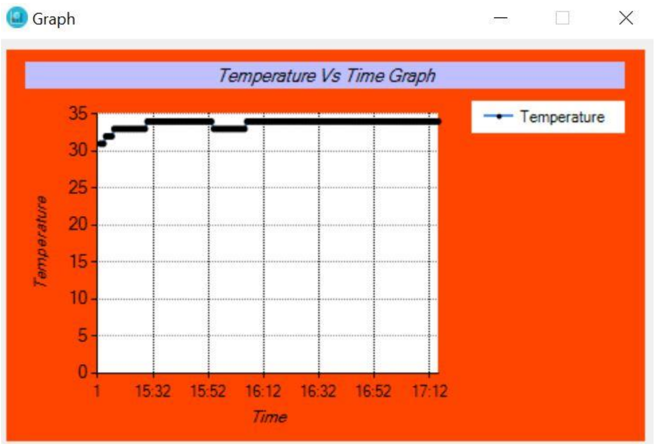


Figure 4.8: Temperature Reading Graph

The above Figure 4.8 depicts the temperature readings at UMP Pekan having readings between 31°C to 34°C over a span of two hours. The readings are measured using DHT-22 temperature humidity sensor.

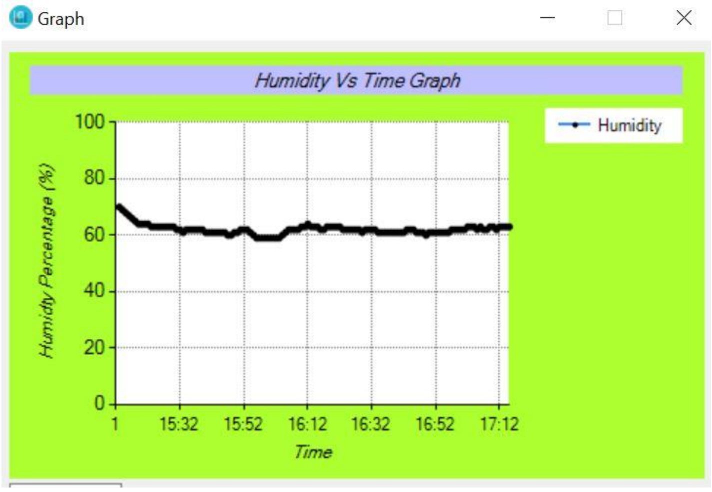


Figure 4.9: Humidity Reading Graph

In Figure 4.9, humidity readings from the monitoring terminal shows a steady level at around 60% humidity with no apparent fluctuations. The readings are measured using DHT-22 temperature humidity sensor.

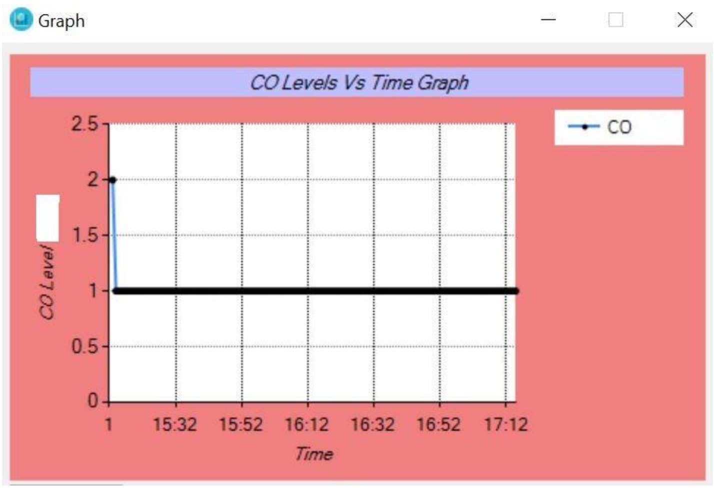


Figure 4.10: CO Level Reading Graph

Figure 4.10 above, the readings of CO level that was recording from the test stays at 1 API throughout the entire test. This might be due to the minimal amount of car exhaust emission in the area. The readings are measured using MQ-135 gas sensor.

4.4.4.2 GSM Service Message

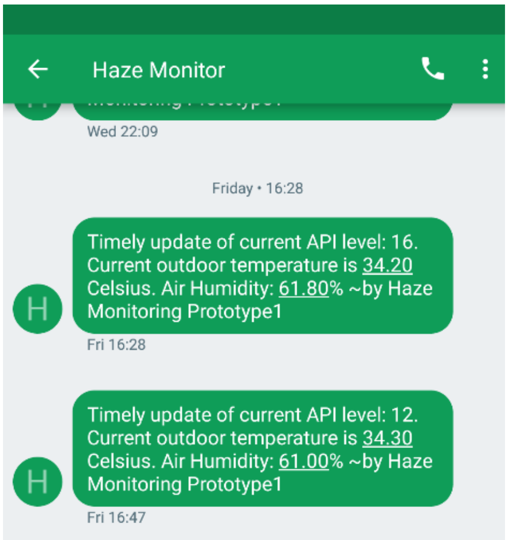


Figure 4.11: SMS Alert Message Every 15 Minutes Via GSM

In the test conducted, the SMS alert is programmed send an update of haze level with every 20minutes interval. The format of the message is displayed in Figure 4.11. To determine who to send the SMS, the designated recipient phone number is programmed into the microcontroller beforehand.

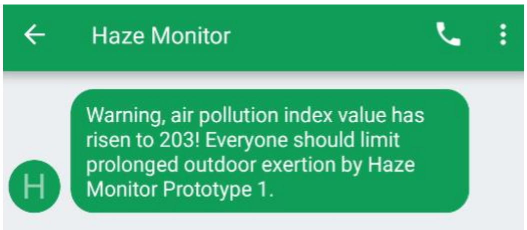


Figure 4.12: SMS Alert Message When Haze Readings Exceed Safe Level

The above Figure 4.12 is a type of SMS response when haze levels goes beyond safe levels which had been programmed to the microcontroller. This would be like an alarm bell where the user should be on high alert and more cautious of the surrounding air quality.

4.4.2 PRELIMINARY TEST 2

Table 4.1: Parameters of Test 2

Date	15th April 2017
Time (hour)	1514 to 1916
Location	UMP Jalan Tegak, Pekan.
SMS INTERVAL	15 minutes
Supposedly No. of SMS	8
No. of SMS Received	7
SMS Consistency	87.5%

A second test was conducted to record the readings from the modules to determine its consistency and reliability. Table 4.1 shows the parameters and results of the test. In a span of two hours, seven SMS out of eight was received in the duration. This data amount to 87.5% consistency of the SMS feature, which had been set to send one every 15 minutes.

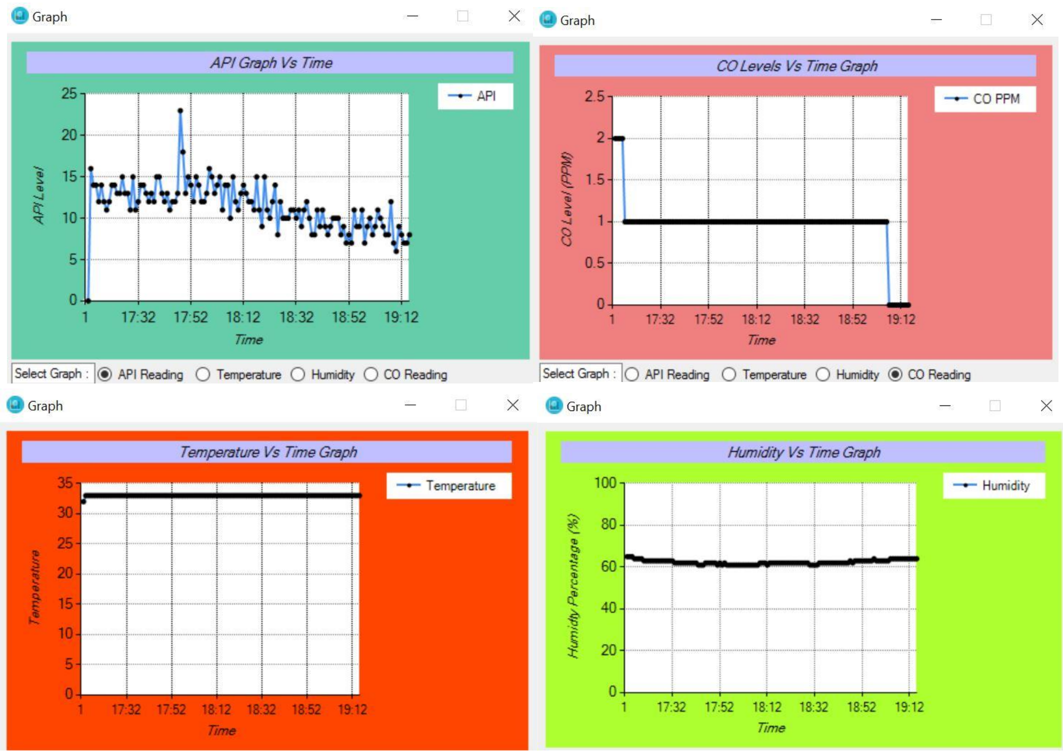


Figure 4.13: Graphical Data of API, CO Level, Temperature & Humidity from Terminal for Test No.2

By looking at Figure 4.13, it is deducible that the API value dropped slightly as dusk approached, from a range of in between 11 and 15 to 6 and 11. This imply that the amount of dust in the air has reduced. Similarly, this trend also applies to the carbon monoxide gas in the air. However, the level of temperature and humidity in the area remains in the same range throughout.

4.4.3 PRELIMINARY TEST 3

Table 4.2: Parameters of Test 3

Date	20th April 2017
Time (hour)	0709 to 1113
Location	UMP Jalan Tegak, Pekan.
SMS Interval	15 minutes
Supposedly No. of SMS	17
No. of SMS Received	17
SMS Consistency	100%

Table 4.2 shows the parameters that were involved in the third test which lasted for 4 hours. Like test 2, at fifteen minutes, a SMS is program to be sent to the users. This time, the SMS consistency was at 100% with seventeen over seventeen SMS were received. This occurrence isn't very unusual as SMS could be stored in a local SMS center when there is no network signal.

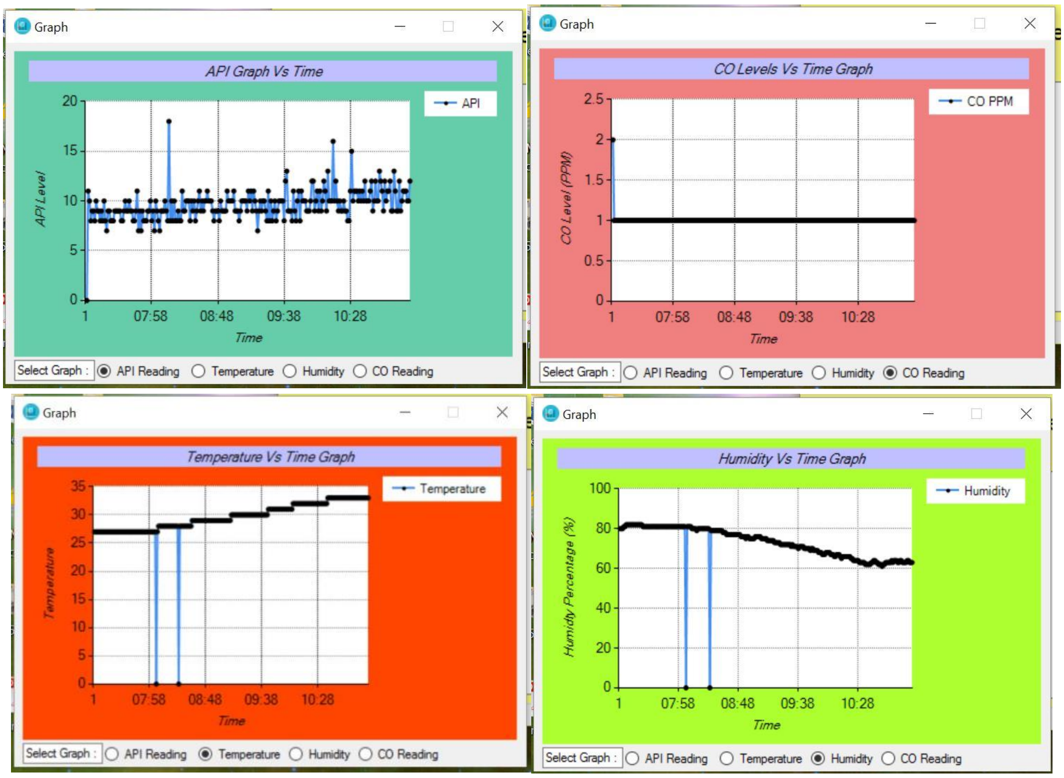


Figure 4.14: Graphical Data of API, CO Level, Temperature & Humidity from Terminal for Test No.3

By observing the graph on Figure 4.15, it can be said that API levels within that 4 hours experience an insignificant yet noticeable increase. Besides that, the temperature graph shows a steady increase in temperature from 27℃ to 33℃, whereas the percentage of humidity decreases with time from 80% to 60%. Apart from that, carbon monoxide levels show consistent readings. From the trend of readings, this set of data matches the behaviour of a normal scenario for a normal morning with temperature rising and humidity dropping and human activities incite dust.

4.5 POWER CONSUMPTION

Haze Monitoring Terminal

Table 4.3: Total Current Consumption of Terminal Unit

Electronic Components	Current Draw (mA)
MQ-135 Gas Sensor	0.09
A6 GSM Module	0.04
Arduino Nano	0.02
DHT-22 Temperature Humidity Sensor	0.0015
NRF24L01 Nordic Module	0.014
GP2Y1010AUF Dust Sensor	0.02
Total	0.1855

From Table 4.3, it is known that the unit is powered by 6 x AA batteries in series which sums up to 9V. We are then able to determine the power draw from the batteries to be:

0.1855 x 9 = 1.6695 W

Haze Monitoring Center

Table 4.4: Total Current Consumption of Center Unit

Electronic Components	Current Draw (mA)
Arduino Nano	0.02
2 x 16 LCD	0.02
NRF24L01 Nordic Module	0.014
Total	0.054

From Table 4.4, it is depicted that the total current consumption of the unit would be 0.054mA. Hence, by knowing that the voltage being supplied is 9V, the total power used would be:

0.054 x 9 = 0.486 W

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

In this chapter, the focus is to discuss about any possible limitations and to provide a proper conclusion for this project. Apart from that, also to propose suitable recommendations for possible future improvements of the project.

5.2 CONCLUSION

With the frequent haze phenomenon in Malaysia, this project will come in handy and bring benefit to the masses. Besides, it could also promote awareness and keep people vigilant of the current air quality. This is a responsibility that everyone should uphold and not only rely on environmental officials to mitigate or resolve the issue. It is through collective effort that we can tackle and overcome this longstanding task.

Towards the end, all objectives of this project were achieved. This project had successfully integrated a GSM (global system for mobile communication) and a radio frequency module into the system to assist in real-time tracking of data. In addition, the system is also able to notify users when haze readings exceed a certain level.

It is sufficed to say that the results from this project is satisfactory, where readings are stable and consistent. Its self-contained battery pack is an added value which makes it portable and mobile, that can be applied in many applications.

5.3 RECOMMENDATIONS FOR FUTURE WORK

Even though this project was a success, there is always still room for improvement to be made. By taking into consideration of limitation imposed on the modules, we can identify and determine the aspects that we could improve on. Following this technical approach, we would have a systematic guideline.

Speaking from a user point of view, it is indeed favourable that we are constantly being updated on the haze readings via short message services. However, this could be further improved by increasing the versatility of system by implementing a two-way communication, where users can prompt the system to send the current haze reading instead of utilizing time interval. On top of that, as good as it already is, the GSM (global system for mobile communication) could be upgraded to GPRS (global packet radio service) which supports mobile data and increases its accessibility. This way, the concept of IOT (internet of things) can be applied and this project could penetrate the market of modern society.

Furthermore, apart from the existing sensors such as DHT-22 temperature humidity sensor, MQ-135 gas sensor and GP2Y1010AUF dust sensor, it is also suggested to add the number of sensors to increase the types of data that is collected from our surrounding. From there, we would have more data to analyse and have a more detailed understanding and comprehension.

REFERENCES

This thesis is prepared based on the following references:

[1] [Online]. Available: http://www.cwb.gov.tw/V7e/knowledge/encyclopedia/me014.htm

[2] World-Health-Organization. 7 Million Premature Deaths Annually Linked to Air Pollution. [Online]. Available: http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/

[3] [Online]. Available http://www.fire.uni-freiburg.de/programmes/un/wmo/wmorep.htm

[4] Vikrant Vij, 2010. "Wireless Communication." Published by Laxmi Publications, Ltd.

[5] Gagliarducci, M., Lampasi, D. A., & Podestà, L. (2007). GSM-based monitoring and control of photovoltaic power generation. Measurement, 40(3), 314-321. doi:http://dx.doi.org/10.1016/j.measurement.2006.05.018

[6] Peersman, C., Cvetkovic, S., Griffiths, P., & Spear, H. (2000). The Global System for Mobile Communications Short Message Service. IEEE Personal Communications, 7(3), 15-23. doi:10.1109/98.847919

[7] Calcante A., Tangorra F. M., Marchesi, G., & Lazzari, M. (2014). A GPS/GSM based birth alarm system for grazing cows. Computers and Electronics in Agriculture, 100, 123-130. doi:http://dx.doi.org/10.1016/j.compag.2013.11.006

[8] Pereira V., Sousa T., Mendes P., Monteiro E., (2004) "Evaluation of Mobile Communication: From Voice Calls to Ubiquitous Multimedia Group Communication", in Proc. Of the 2nd International Working Conference on Performance Modelling and Evaluation of Heterogeneous Networks, HET-NET's04, IIkley, West Yorkshire, U.K.,

[9] Al-Ali, A. R., Khaliq, A., & Arshad, M. (2004, 12-15 May 2004). GSM-based distribution transformer monitoring system. Paper presented at the Electrotechnical Conference, 2004. MELECON 2004. Proceedings of the 12th IEEE Mediterranean.

[10] Peijiang, C., & Xuehua, J. (2008, 19-20 Dec. 2008). Design and Implementation of Remote Monitoring System Based on GSM. Paper presented at the Computational Intelligence and Industrial Application, 2008. PACIIA '08. Pacific-Asia Workshop on.

[11] Liu, H., Meng, Z., & Cui, S. (2007, 21-25 Sept. 2007). A Wireless Sensor Network Prototype for Environmental Monitoring in Greenhouses. Paper presented at the 2007

International Conference on Wireless Communications, Networking and Mobile Computing.

[12] Tseng, C.-L., Jiang, J.-A., Lee, R.-G., Lu, F.-M., Ouyang, C.-S., Chen, Y.-S., & Chang, C.-H. (2006). Feasibility study on application of GSM–SMS technology to field data acquisition. Computers and Electronics in Agriculture, 53(1), 45-59.doi:10.1016/j.compag.2006.03.005

[13] Jiang, J.-A., Tseng, C.-L., Lu, F.-M., Yang, E.-C., Wu, Z.-S., Chen, C.-P., . . . Liao, C.-S. (2008). A GSM-based remote wireless automatic monitoring system for field information: A case study for ecological monitoring of the oriental fruit fly, Bactrocera dorsalis (Hendel). Computers and Electronics in Agriculture, 62(2), 243-259. doi:http://dx.doi.org/10.1016/j.compag.2008.01.005

[14] Othman, K. A., Abdullah, E. H., Li, N., & Rashid, N. E. A. (2014, 6-8 May 2014). GSM wireless technology implementation in haze monitoring. Paper presented at the Digital Information and Communication Technology and it's Applications (DICTAP), 2014 Fourth International Conference on.

[15] Tang, Z., Shuai, W., & jun, L. (2011). Remote Alarm Monitor System Based On GSM and ARM. Procedia Engineering, 15, 65-69. doi:http://dx.doi.org/10.1016/j.proeng.2011.08.014

[16] Hu, J. M., Li, J., & Li, G. H. (2012, 1-3 Nov. 2012). Automobile Anti-theft System Based on GSM and GPS Module. Paper presented at the Intelligent Networks and Intelligent Systems (ICINIS), 2012 Fifth International Conference on.

[17] Chien, H. C. (2014). Smoke Sensor: Google Patents

[18] Suyuti A., Tola M., Muh. Saleh Pallu, Harun N., Syafaruddin, Takashi Hiyama, 2013 "Simple And Portable Gas Emission Detector Design Using Microcontroller ATMEGA", ICIC Express Letters, Part B: Application ICIC International c2013 ISSN 2185-2766, Volume 4, Number 1, February 2013 pp.13-18

[19] Nograles, H. A. H., Agbay, C. P. D., Flores, I. S. L., Manuel, A. L., & Salonga, J. B. C. (2014, 6-8 May 2014). Low cost internet based wireless sensor network for air pollution monitoring using Zigbee module. Paper presented at the Digital Information and Communication Technology and it's Applications (DICTAP), 2014 Fourth International Conference on.

[20] We are Arduino [Online]. Available https://www.arduino.cc/en/Main/AboutUs

[21] Steven F. Barrett, "Arduino Microcontroller Processing For Everyone", Published by Morgan & Claypool Publishers, 2nd Edition (18. Juni 2012)

[22] TGS 2602-for the detection of Air Contaminants [Online]. Available: http://fr.rs-online.com/webdocs/065f/0900766b8065f325.pdf

[23] Hu, K., Sivaraman, V., Luxan, B. G., & Rahman, A. (2016). Design and Evaluation of a Metropolitan Air Pollution Sensing System. IEEE Sensors Journal, 16(5), 1448-1459. doi:10.1109/JSEN.2015.2499308

[24] Department of Environment Malaysia (2000). A Guide to Air Pollution Index (API) in Malaysia. Retrieved from: https://aqicn.org/images/aqi-scales/malaysia-api-guide.pdf

TABLE AND FIGURE REFERENCE

1. Vikrant Vij. “Wireless Communication.” Published by Laxmi Publications, Ltd. Pg. 89
2. Arduino Comparison Guide [Online Image]. Retrieved on November 21th 2016, From https://learn.sparkfun.com/tutorials/arduino-comparison-guide
3. TGS 2602-for the detection of Air Contaminants Retrieved on December 1st 2016, From http://fr.rs-online.com/webdocs/065f/0900766b8065f325.pdf
4. Compare Board Specs. Retrieved on November 21th 2016, From https://www.arduino.cc/en/Products/Compare
5. Arduino Uno. Retrieved on November 24th 2016, From http://www.arduino.org/products/boards/arduino-uno
6. GPRS GSM Module A6. Retrieved on November 24th 2016, From http://picclick.ca/Quad-band-A6-GPRS-GSM-Module-Adapter-Board-Plate-252509609051.html
7. Interfacing MQ2 to Arduino-Gas Sensor for Smoke-Butae-CH4 and LPG. Retrieved on November 24th 2016, From http://www.circuitstoday.com/interfacing-mq2-to-arduino
8. Arduino Community Logo. Retrieved on November 24th 2016, From https://www.arduino.cc/en/Trademark/CommunityLogo
9. GSM GPRS A6 Module. Retrieved on November 24th 2016, From http://www.electrodragon.com/w/GSM_GPRS_A6_Module
10. Optical Dust Sensor GP2Y1010AUF Retrieved on April 17th 2017. From https://www.itead.cc/gp2y1010au0f-compact-optical-dust-sensor.html
11. Technical Data MQ-135 Gas Sensor. Retrieved on April 17th 2017. From https://www.olimex.com/Products/Components/Sensors/SNS-MQ135/resources/SNS-MQ135.pdf

APPENDICES

A PROGRAM CODE FOR HAZE MONITORING TERMINAL

```
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>
#include <SoftwareSerial.h>
SoftwareSerial mySerial(3, 4); // RX, TX
#include "DHT.h"
#define DHTPIN 7
#define DHTTYPE DHT22
DHT dht(DHTPIN, DHTTYPE);
#define CE_PIN   9
#define CSN_PIN 10
const byte slaveAddress[5] = {'R','x','A','A','A'};
int dataToSend[7];
RF24 radio(CE_PIN, CSN_PIN); // Create a Radio

int measurePin = A3;
int ledPower = 8;
int samplingTime = 280;
int deltaTime = 40;
int sleepTime = 9680;
float voMeasured = 0;
float calcVoltage = 0;
float dustDensity = 0;
float density = 0;
double  ppmapi = 1;
int densityapi = 0;
int ppm1 = 0;
int api;
int counter = 0;
int counter1 = 500;
int maxCount = 1500;
char phone_no[]="0133905227";
int aray[51];
int aray135[11];
int i, j;
```

```
int z = 1;
float sum, sum135;
int newapi;
int fan = 5;
int gsm = 6;

#define        MQ135PIN                   (1)
#define        RL_VALUE_MQ135             (1)
#define        RO_CLEAN_AIR_FACTOR_MQ135      (3.59)  ,
#define        READ_SAMPLE_INTERVAL        (5)
#define        READ_SAMPLE_TIMES           (2)
float          Ro = 1.6;
void setup(){
  Serial.begin(9600);
  mySerial.begin(115200);
  dht.begin();
  pinMode(ledPower,OUTPUT);
  pinMode(fan, OUTPUT);
  digitalWrite(fan, HIGH);
  digitalWrite(gsm, HIGH);

    radio.begin();
    radio.setDataRate( RF24_250KBPS );
    radio.setRetries(3,5); // delay, count
    radio.openWritingPipe(slaveAddress);
delay(2000);
digitalWrite(gsm,LOW);
}

void loop()
{
 particlesensor();
 mq135sensor();
  float h = dht.readHumidity();
  float t = dht.readTemperature();
  density = dustDensity*1000;
  APIcal();
        dataToSend[0] = t;
        dataToSend[1] = h;
        dataToSend[2] = density;
        dataToSend[3] = ppm1;
        dataToSend[4] = newapi;
```

```
        dataToSend[5] = counter;
        dataToSend[6] = 69;
        send();
counter++;
counter1++;
  Serial.print("Temperature = ");
  Serial.print(t);
  Serial.print("      Humidity = ");
  Serial.print(h);
  Serial.print("      Dust Density: ");
  Serial.print(density);
  Serial.print("      CO ppm = ");
  Serial.println(ppm1);
  Serial.print("Air API = ");
  Serial.println(newapi);
   Serial.print(i);
   Serial.print("   ");
   Serial.print(ppmapi);
   Serial.print("   ");
   Serial.print(densityapi);
   Serial.print("   ");
   Serial.println(MQGetGasPercentage(MQRead(MQ135PIN)/Ro) );
   Serial.print("   ");
   Serial.println(counter );

 delay(400);
sum = 0;
i++;
aray[i] = api;
if(i == 50){
  for(i = 1; i < 51; i++)
{
  sum += aray[i];
}
sum = sum/50;
newapi = sum;
i=0;
}

if ( (newapi >100) && (newapi <150) && (counter1 > 500)){
    mySerial.print("AT+CMGF=1\r");    //Because we want to send the SMS in text
mode
```

```
    delay(2000);
    mySerial.print("AT+CMGS=\"");
    mySerial.print(phone_no);
    mySerial.write(0x22);
    mySerial.write(0x0D);  // hex equivalent of Carraige return
    mySerial.write(0x0A);  // hex equivalent of newline
    delay(2000);
    mySerial.print("Alert, air pollution index value has risen to ");
    mySerial.print(newapi);
    mySerial.print("! Children and adult with respiratory disease, limit prolonged outdoor
exertion by Haze Monitor Prototype ~");
    mySerial.print(z);
    delay(100);
    mySerial.println((char)26);
    delay(2000);
    counter1 = 0;
  }

 if ( (newapi>150) && (counter1 > 500)){
    mySerial.print("AT+CMGF=1\r");    //Because we want to send the SMS in text
mode
    delay(2000);
    mySerial.print("AT+CMGS=\"");
    mySerial.print(phone_no);
    mySerial.write(0x22);
    mySerial.write(0x0D);  // hex equivalent of Carraige return
    mySerial.write(0x0A);  // hex equivalent of newline
    delay(2000);
    mySerial.print("Warning, air pollution index value has risen to ");
    mySerial.print(newapi);
    mySerial.print("! Everyone should limit prolonged outdoor exertion by Haze Monitor
Prototype ~");
    mySerial.print(z);
    delay(100);
    mySerial.println((char)26);
    delay(2000);
    counter1 = 0;
  }

if (counter > maxCount){
    mySerial.print("AT+CMGF=1\r");    //Because we want to send the SMS in text
mode
```

```
    delay(2000);
    mySerial.print("AT+CMGS=\"");
    mySerial.print(phone_no);
    mySerial.write(0x22);
    mySerial.write(0x0D);  // hex equivalent of Carraige return
    mySerial.write(0x0A);  // hex equivalent of newline
   delay(2000);
    mySerial.print("Timely update of current API level: ");
    mySerial.print(newapi);
    mySerial.print(". Current outdoor temperature is ");
    mySerial.print(t);
    mySerial.print(" Celsius. Air Humidity: ");
    mySerial.print(h);
    mySerial.print("% by Haze Monitor Prototype ~");
    mySerial.print(z);
    delay(100);
    mySerial.println((char)26);
    delay(2000);
    counter = 0;
    z++;
 }

}

void particlesensor()
{  digitalWrite(ledPower,LOW);
  delayMicroseconds(samplingTime);
  voMeasured = analogRead(measurePin);
  delayMicroseconds(deltaTime);
  digitalWrite(ledPower,HIGH);
  delayMicroseconds(sleepTime);
  calcVoltage = voMeasured * (5.0 / 1024.0);
  dustDensity = 0.17 * calcVoltage - 0.1;
     if ( dustDensity < 0)
  {
    dustDensity = 0.00;
  }
}

void mq135sensor(){
    sum135 = 0;
j++;
```

```
aray135[j] =MQGetGasPercentage(MQRead(MQ135PIN)/Ro);;
if(j == 10){
  for(j = 1; j < 11; j++)
{
  sum135 += aray135[j];
}
sum135 = sum135/10;
ppm1 = sum135 ;
j=0;
}
}

float MQResistanceCalculation(int raw_adc)
{
  return ( ((float)RL_VALUE_MQ135*(1023-raw_adc)/raw_adc));
}

float MQRead(int mq_pin)
{
  int i;
  float rs=0;
  for (i=0;i<READ_SAMPLE_TIMES;i++) {
    rs += MQResistanceCalculation(analogRead(mq_pin));
    delay(READ_SAMPLE_INTERVAL);
  }
  rs = rs/READ_SAMPLE_TIMES;
  return rs;
}

int MQGetGasPercentage(float rs_ro_ratio)
{
    return (pow(10,(1.457*pow((log10(rs_ro_ratio)), 2) - 4.725*(log10(rs_ro_ratio)) +
2.855)));
}

void send() {
    bool rslt;
    rslt = radio.write( &dataToSend, sizeof(dataToSend) );
}
void APIcal(){
if ( (density >= 0) && (density < 50)){
  densityapi = density;
```

```
}
else if ( (density >= 50) && (density < 350)){
  densityapi = ((density -50)/2) + 50;
}
else if ( (density >= 350) && (density < 420)){
  densityapi = (density -350)*3.5/5 + 200;
}
else if ( (density >= 420) && (density < 500)){
  densityapi = (density - 420)*5/4 + 300;
}
else if ( (density >= 500) && (density < 600)){
  densityapi = (density -500) + 400;
}

if ( 0 <= ppm1 < 9){
ppmapi = (100/9)*ppm1;
}
else if ( 9<= ppm1 < 15){
ppmapi = (ppm1-9)/0.3*5 + 9;
}
else if ( 15 <= ppm1 < 30){
 ppmapi = (ppm1 -15)/0.75*5 + 15;
}
else if ( 30 <= ppm1 < 50){
 ppmapi = (ppm1- 30)*10 + 30;
}

api = densityapi;
//if (ppmapi < densityapi){
//   api = densityapi;
//  }
//else if (ppmapi > densityapi){
//    api = ppmapi;
//  }
}
```

B PROGRAM CODE FOR HAZE MONITORING CENTER

```
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>
#include <LiquidCrystal.h>
#define CE_PIN   9
#define CSN_PIN 10
const byte thisSlaveAddress[5] = {'R','x','A','A','A'};
RF24 radio(CE_PIN, CSN_PIN);
int dataReceived[7]; // this must match dataToSend in the TX
bool newData = false;

LiquidCrystal lcd(7, 6, 2, 3, 4, 5);
int screen = 1;
int upstate = 0;
int downstate = 0;
int lcdstate = 0;
int timer;

void setup() {
  lcd.begin(16, 2);              // start the library
  lcd.setCursor(0,0);
  lcd.print("Haze Monitoring");
  lcd.setCursor(0,1);
  lcd.print("Terminal by Yang");
  Serial.begin(9600);
  radio.begin();
  radio.setDataRate( RF24_250KBPS );
  radio.openReadingPipe(0, thisSlaveAddress);
  radio.startListening();
  pinMode(A1 , INPUT);
  pinMode(A2, INPUT);
  delay(2000);
  lcd.setCursor(0,0);
  lcd.print("Initiation      ");
  lcd.setCursor(0,1);
  lcd.print("Wait ~          ");
  for ( int i = 0; i<10; i++){
  timer = 10 -i;
  if (timer == 9){
```

```
    lcd.setCursor(0,1);
    lcd.print("Wait ~          ");
    }
    lcd.setCursor(7,1);
    lcd.print(timer);
    delay(1000);
    }
    delay(1000);
}

void loop(){

sample_data:  getData();  showData();
          if ( dataReceived[6] != 69){
            lcd.setCursor(0,0);
            lcd.print("Nrf not paired  ");
            lcd.setCursor(15,0);
            lcd.print((char)47);
            lcd.setCursor(0,1);
            lcd.print(" wait 4 seconds ");
          }
          else {
          lcdconfig();
          }
          dataReceived[6]=0;
upstate = digitalRead(A1);
downstate = digitalRead(A2);

if (upstate == HIGH && downstate == LOW){
  lcdstate = 1;
}
else if (upstate == LOW && downstate ==HIGH){
  lcdstate = 2;
}
else {lcdstate = 0;}
// read the buttons
  switch (lcdstate)               // depending on which button was pushed, we perform an
action
 {
   case 1:
     {
     screen = screen - 1;
```

```
     delay(300);
     break;
     }
   case 2:
     {

     screen = screen + 1;
     delay(300);
     break;
     }
 }
 delay(650);
}

void getData() {
    if ( radio.available() ) {
        radio.read( &dataReceived, sizeof(dataReceived) );
        newData = true;
    }
}

void showData() {
    if (newData == true) {
    Serial.print(",");
    Serial.print(dataReceived[0]); //Humidity =
    Serial.print(",,");
    Serial.print(dataReceived[1]); //DDensity =
    Serial.print(",,,");
    Serial.print(dataReceived[2]); //CO ppm
    Serial.print(",,,,");
    Serial.print(dataReceived[3]); //Air API =
    Serial.print(",,,,,");
    Serial.print(dataReceived[4]); //Counter =
    Serial.print(",,,,,,");
    Serial.print(dataReceived[5]);
    Serial.println(",,,,,,,");
        newData = false;
    }
}

void lcdconfig(){
  if (screen >4){
```

```
  screen = 4;
  }
if (screen <1){
  screen = 1;
}
switch (screen){
  case 1:{
lcd.setCursor(0,0);
lcd.print("Temperature:    ");
lcd.setCursor(12,0);
lcd.print(dataReceived[0]);
lcd.setCursor(14,0);
lcd.print((char)223);
lcd.setCursor(15,0);
lcd.print((char)67);
lcd.setCursor(0,1);
lcd.print("Humidity:       ");
lcd.setCursor(10,1);
lcd.print(dataReceived[1]);
lcd.setCursor(13,1);
lcd.print((char)37);}
break;
  case 2:{
lcd.setCursor(0,0);
lcd.print("Humidity:       ");
lcd.setCursor(10,0);
lcd.print(dataReceived[1]);
lcd.setCursor(13,0);
lcd.print((char)37);
lcd.setCursor(0,1);
lcd.print("DustDensity:    ");
lcd.setCursor(13,1);
lcd.print(dataReceived[2]);}
break;
  case 3:{
lcd.setCursor(0,0);
lcd.print("DustDensity:    ");
lcd.setCursor(13,0);
lcd.print(dataReceived[2]);
lcd.setCursor(0,1);
lcd.print("CO:    ppm      ");
lcd.setCursor(4,1);
```

```
  lcd.print(dataReceived[3]);}
  break;
    case 4:{
  lcd.setCursor(0,0);
  lcd.print("CO:    ppm       ");
  lcd.setCursor(4,0);
  lcd.print(dataReceived[3]);
  lcd.setCursor(0,1);
  lcd.print("API:             ");
  lcd.setCursor(6,1);
  lcd.print(dataReceived[4]);}
  break;
  }
}
```

C. CONFERENCE PAPER

WIRELESS GSM HAZE MONITORING SYSTEM

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Abstract— **Haze is a condition in the atmosphere that hinders visibility in an affected area. Malaysia is a recurring country which haze exists and poses a threat to public health. For a country, which is frequented by the occurrence of haze, air quality readings are not easily accessible by the public. Hence, portable units equipped with sensors and communicative devices could be an alternative to acquire the data. With sensory units that can measure temperature, humidity, carbon monoxide level and dust density along with a global system for mobile communication module and Radio Frequency (RF) module, users will be able to receive readings via Global System for Mobile Communications (GSM) for Short Message Service (SMS) or view them from a monitor. This unit comes in a set of two, a monitoring terminal and a monitoring center. All sensor readings will be acquired from the monitoring terminal and be sent to portable monitoring center for a visual display.**

Keywords—Haze;Portable;RF;GSM;SMS;

I. INTRODUCTION

From meteorological standpoint, it is an atmospheric phenomenon where a conglomeration of small dry suspended particles in the atmosphere named lithometeor. In layman term, haze is a condition in the atmosphere that hinders visibility in an affected area. Haze typically comprises of dust and smoke particles that causes the scattering of light when sunlight is present. They are usually white in colour in the atmosphere and appear to be yellowish or orange-reddish when against a bright background [1]. Therefore, when haze is unmistakably present in the atmosphere, our horizontal visibility is damped substantially.

Relating to everything that exist in nature, when is in excessive amount, it could conjure a threat to topple the equilibrium of a system. Likewise, as haze looms over our clear sky disproportionately, it accumulates and when air flow is stagnant or restricted, the high density of haze could very well affect our health, respiratory difficulties and impairs visibility. The effects of haze are detrimental and unfavourable for any outdoor activities. To quantify the severity of haze, various government agencies use an easy to comprehend air quality index which measure the concentration of air pollutant in the air. The air quality index is translated from the data acquired via an air monitoring unit installed at a given location along with a particle sensor. Air quality standards are typically classified into different ranges. Each of the range is assigned with a descriptor, colour code and public health advisory.

According a report released by World Health Organisation (WHO) in year 2014, low and middle-income countries around Western Pacific Region and South East Asia were facing countless outdoor air pollution related issue with 2.6 million death cases [2]. For if we could remember, the occurrence of haze had become an annual affair for the local communities of South East Asia. The communities in this region are always on high alert for any signs or reports or haze. Ever since the mid of 20th century, records of transboundary haze occurring regularly have become a common event. The most observable root cause of these haze is pertaining to large scale illegal open burning. They are associated with many irresponsible farmers or land owners who operate only with their best interest in mind, neglecting social responsibility via illegal land clearing by opening burning. They are associated with many irresponsible farmers or land owners who operate only with their best interest in mind, neglecting social responsibility via illegal land clearing by opening burning. As some claims that practices such as slash-and-burn are especially rampant in Indonesia. Cases like these caught public attention and on June 1998, the World Meteorological Organization (WMO) conducted a regional workshop relating to transboundary smoke and haze in Southeast Asia as part of its effort to curb widespread air pollution and environment problems around the vicinity [3]. The workshop is to highlight and manage haze episodes which disrupted the tourist industry, public health, agricultural production, civil aviation operations and maritime shipping.

Conventionally, on-site haze monitoring station usually required someone to gather and record haze levels in an area. Most of the times, it consumes time, money and manpower to operate the station. Upon erecting the station, either an electric cable would be connected to the station for power and data acquisition or in-charged personnel is needed to check and consolidate the data from time to time. As simple as it may sound, it would be a hassle if the station located on a mountain side or deep in the forest. Thus, having to implement a wireless system with a monitoring terminal and monitoring center would greatly improve efficiency, where the data could be remotely monitored and analyse in real time.

This paper presents an integrated haze monitoring system which utilize GSM wireless technology and RF wireless technology to allow real-time tracking and monitoring of haze level in its vicinity. Where the user will be notified via SMS at an interval rate or when haze level exceeds safety limit.

II. LITERATURE REVIEW

A. WIRELESS GSM (GLOBAL SYSTEM FOR WIRELESS COMMUNICATION)

GSM network has the advantages of wide covering area, long communication distance mature technology, and sound communication effect and et-cetera [4]. As stated by SMS point-point (SMSPP) standard defined by ETSI (European Telecommunication Standards Institute), this function relies on the nature and of the SMS origin and destination. Whenever a message is send by a mobile station and is terminated, in the absence low connectivity or no connection, a local SMS Center will store it and tries to send it repeatedly for three days as soon as a mobile station is available. Frequency bands in which the GSM network could be operated in Malaysia and most of the world are 900MHz or 1800 MHz [5].

Typically, a GSM module are controlled using industry standard AT command, which is an abbreviation for Attention. Every command line begins with “at” or “AT”, it is a prefix to inform the module the starting line of command. However, they’re also used to control wired dial-up modem. Each of the modem interfaces to the host through a USART (universal synchronous/asynchronous serial receiver-transmitter), that is automatically detected by the operating system. As a clarification, when the term mobile station is mentioned, it refers to the modem. Furthermore, AT commands consist of three parts, starting with AT, then by a command and ended with a line termination character <cr>.

A feasibility study was conducted on application of GSM-SMS technology to field data acquisition [6]. It is based on field data collection prototype system that composed of field monitoring and host control platforms. Using GSM-SMS based communication architecture to developed a short message format that is used to monitor farming area and record field data, such as humidity, wind speed, number of pest captured and temperature. There are four advantages to mobile communication technology, they are low power requirement, covers a wide range of area, user data can be stored in GSM service centre temporarily and having group broadcast function. Besides that, SMS used in filed data acquisition do not need long cables, contains encryption to protect SMS data and during transmission failure, retransmission can be configured again. Coding and decoding of data between field monitoring and host control platforms can be achieved by predefining data format of SMS. Generally, 160 bytes is the maximum length of a SMS message. As a means to verify the correctness and feasibility of SMS data transmitting across the field, a simple trap device for moth was integrated in the field monitoring platform with a 8051 chip as a counter. Host control platform prototype was create using Visual Basic 6.0 on a PC for the graphical user interface program. The data transmission had a test record of 100% data accuracy rating from performance rating test.

B. SMOKE SENSOR

Smoke sensors are devices that can detect various types of particle in the air, commonly found in smoke detector which in the presence of anomaly would give off an alarm. There are two types of conventional smoke sensor that are typically found, one of which uses an optical smoke sensing unit, where a side of its internal wall will emit light and be received by another side of its wall. Contrary to that, there is also the ionization smoke sensing unit, this concept is similar to an inductor which is able to measure smoke particle smaller than an optical sensor, having cavity in its interior that allows particle to flow through which directly affect the current [7]

In a simple research done by Ansar Suyuti and her partners on portable gas emission design using microcontroller [8]. Air pollutant that normally exist in the air are O_2, SO_2, CO, NO_x, SO_4 gaseous and dust particle with heavy metals. Thus smoke sensor with high sensitivity should be implemented to in detecting air pollution or haze. Also mentioned are the types of sensors used in the study, among them are KE25 to detect oxygen, MQ136 for SO_2, MQ7 for CO, TGS2201 for NO_x and MQ2 for opacity of smoke in the air.

Furthermore, research by Abdul Hadi Nograles H. on low cost internet based wireless sensor network for air pollution monitoring using zigbee module, mentioned that MQ2 smoke sensor is able to detect 7 different types of gas compounds and at the same time commercially available [9].This sensor's sensitivity mainly depends on the ratio of sensor resistance (Rs) during expose to smoke and the initial sensor resistance reading, Rs/Ro then being converted to Parts Per Million (PPM) figure using designated equations.

C. ARDUINO

Arduino uses a simple programming language derived from C/C++ language in Arduino Software (IDE), to top that up, it a cross platform software where it could run on Windows, Mac OS X and Linux. Arduino products are built to accommodate an open source hardware and software, which translate to openly sharing its development to stimulate fresh ideas among users and further advance its concept [10]. Arduino products are program using Arduino Development Environment where interfacing and burning a code into an Arduino is done. One of the product called Arduino Uno is built upon ATmega328 chipset, connecting to a computer via USB port. Another product would the Arduino Mega, slightly bulkier than Uno with added ports is based on Atmega1280 chipset. Sketches are what we use write our program in an Arduino Software which would be later saved in the form of a file extension .ino. Table 2.1 below is a comparison of specifications between Arduino Uno and Mega:

III. METHODOLOGY

From Figure 1 and Figure 2 below, it shows the completed hardware of the project. With Figure 1 showing the portable out on the field monitoring terminal unit where data will be collected from and in Figure 2, the monitoring center unit where data will be received for display and logging purpose.

Figure1: Monitoring Terminal

Figure 2: Monitoring Center

A. BLOCK DIAGRAM OF THE MODULES

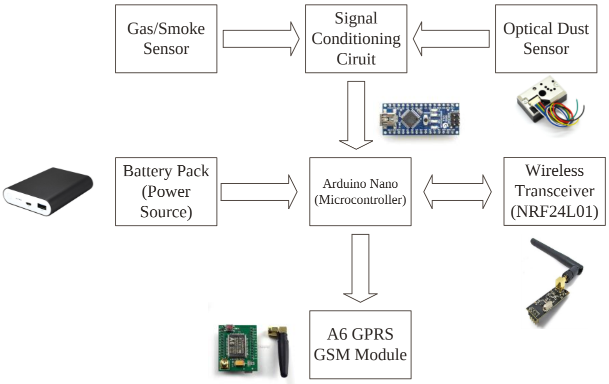


Figure 3: Block Diagram of Haze Monitoring Terminal

Figure 3 depicts the block diagram of the haze monitoring terminal. The hardware that are integrated into this comprises of data collections, data processing and data transmission. Both gas sensor and optical dust sensor are used for data collection and data processing, while the GSM module and RF transceiver is used for data transmission.

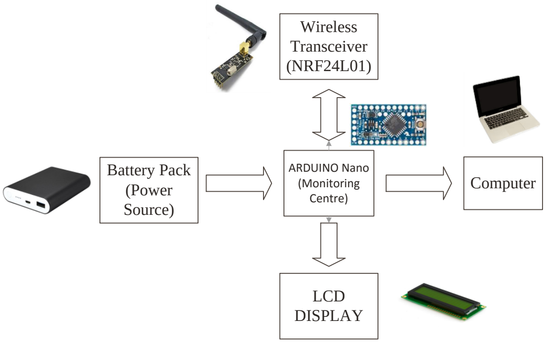


Figure 4: Block Diagram of Haze Monitoring Center

In Figure 4, the block diagram shown is for haze monitoring center. This unit is involving in data reception, data visualization and data logging. A computer would be required to plot the data into graphical form and data logging.

B. SOFTWARE

The software that was used to preload or program the Arduino is open-source Arduino 1.8.2 software. It has its standalone cross platform user interface which contain a text editor for writing code and a series of menu.

Besides that, Visual Studio 2015 was used to make a graphical user interface implementing C# to present, record, tabulate and save data from the haze monitoring terminals. This serve as a handy add-on to the project for better data presentation and analysis.

IV. RESULTS AND DISCUSSION

The range of value in Table 1 will act as a reference as to determine the quality of the air in terms of Air Pollution Index (API). Each category has different level of classification of health indicator and warning as seen in the table.

API	Air Pollution Level
0 - 50	Good
51 - 100	Moderate
101 - 200	Unhealthy
201 - 300	Very Unhealthy
301 and above	Hazardous

Table 1: Classification of Air Quality

Following Table 2, the location for data collection is UMP Jalan Tegak, Pekan. Around the vicinity of this area are mostly covered with trees and bushes where vehicle movements are few and seldom. Observation was done for 4 hours continuously from 0709 hour to 1113 hour with SMS was prompt to send every 15 minutes' interval. Data collected by the system is converted into Air Pollution Index (API) covertly from parts per million (PPM)

Date	20th April 2017
Time (hour)	0709 to 1113
Location	UMP Jalan Tegak, Pekan.
SMS Interval	15 minutes
Supposedly No. of SMS	17
No. of SMS Received	17
SMS Consistency	100%

Table 2: Parameters of The Experiment

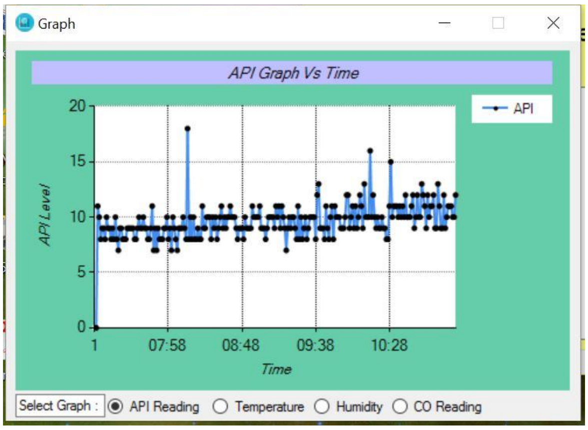


Figure 5: Graph Of Sample Air Pollution Index Collected

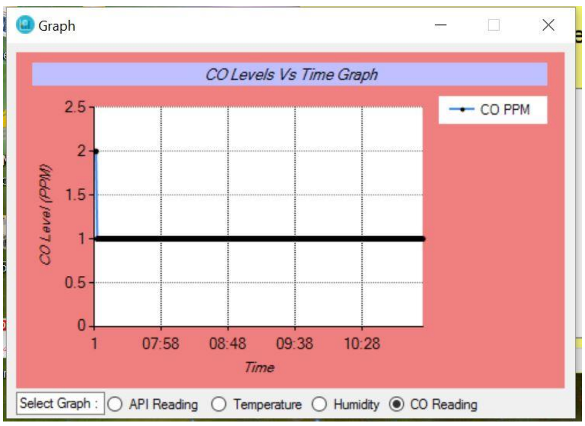


Figure 6: Graph Of Sample Carbon Monoxide Level

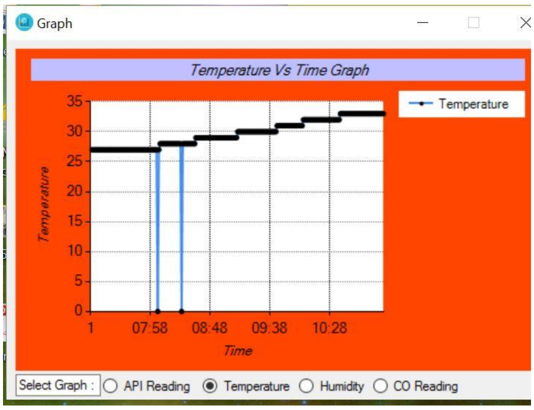


Figure 7: Graph of Sample Temperature Collected

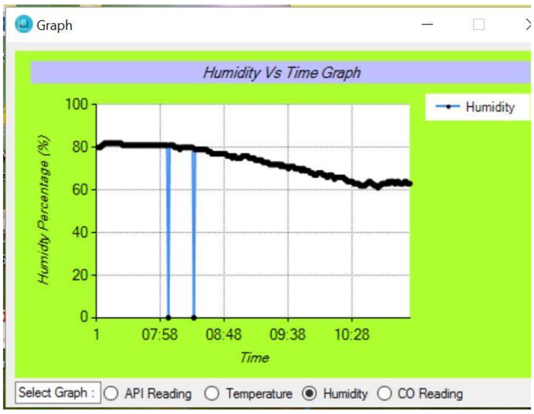


Figure 8: Graph of Sample Humidity Percentage Collected

By observing the graph on Figure 5, it can be said that API levels within that 4 hours experience an insignificant yet noticeable increase. The range of the value falls between 7 to 17, which in this case, air quality is good according to Table 1.

Besides that, in Figure 7 and Figure 8, the temperature graph shows a steady increase in temperature from 27℃ to 33℃, whereas the percentage of humidity decreases with time from 80% to 60%. Apart from that in Figure 6, carbon monoxide levels show consistent readings. From the trend of readings, this set of data matches the behavior of a normal scenario for a normal morning with temperature rising and humidity dropping and human activities incite dust. On top of that, Pekan District is a place with abundance greenery with minin hassling and bustling compare to a city.

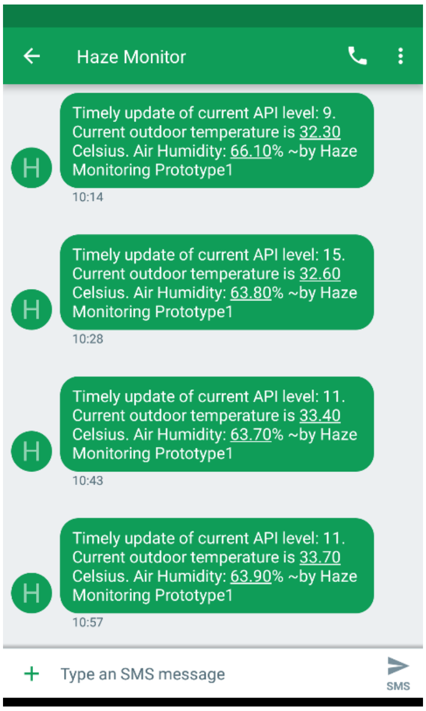


Figure 9: SMS Update on Every Interval

The Figure 9 above portray the SMS received from GSM module in terminal unit functioning well as intended. Update message are sent at an interval rate of 15minutes along with content of message displaying API level, temperature and air humidity level. This way, it is very convenient to the user to acquire readings with minimal effort.

V. CONCLUSION

This project had successfully integrated a GSM (global system for mobile communication) and a radio frequency module into the system to assist in real-time tracking of data. In addition, the system is also able to notify users when haze readings exceed a certain level.

It is sufficed to say that the results from this project is satisfactory, where readings are stable and consistent. Its self-contained battery pack is an added value which makes it portable and mobile, that can be applied in many applications.

ACKNOWLEDGEMENT

The authors would like to express gratitude and acknowledge the Faculty of Manufacturing Engineering, Universiti Malaysia Pahang for continuous support.

REFERENCES

(1) Central Weather Bureau – Weather Phenomenon, Haze. Internet: http://www.cwb.gov.tw/V7e/knowledge/encyclopedia/me014.htm

(2) World-Health-Organization. 7 Million Premature Deaths Annually Linked to Air Pollution. Internet:: http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/I.S.

(3) WMO Workshop on Regional Transboundary Smoke and Haze in Southeast Asia. Internet: www.fire.uni-freiburg.de/programmes/un/wmo/wmorep.htm

(4) Calcante A., Tangorra F. M., Marchesi, G., & Lazzari, M. (2014). A GPS/GSM based birth alarm system for grazing cows. Computers and Electronics in Agriculture, 100, 123-130. doi:http://dx.doi.org/10.1016/j.compag.2013.11.006

(5) Pereira V., Sousa T., Mendes P., Monteiro E., (2004) “Evaluation of Mobile Communication: From Voice Calls to Ubiquitous Multimedia Group Communication”, in Proc. Of the 2nd International Working Conference on Performance Modelling and Evaluation of Heterogeneous Networks, HET-NET’s04, IIkley, West Yorkshire, U.K.,

(6) Tseng, C.-L., Jiang, J.-A., Lee, R.-G., Lu, F.-M., Ouyang, C.-S., Chen, Y.-S., & Chang, C.-H. (2006). Feasibility study on application of GSM–SMS technology to field data acquisition. Computers and Electronics in Agriculture, 53(1), 45-59.doi:10.1016/j.compag.2006.03.005

(7) Chien, H. C. (2014). Smoke Sensor: Google Patents

(8) Suyuti A., Tola M., Muh. Saleh Pallu, Harun N., Syafaruddin, Takashi Hiyama, 2013 “Simple And Portable Gas Emission Detector Design Using Microcontroller ATMEGA”, ICIC Express Letters, Part B: Application ICIC International c2013 ISSN 2185-2766, Volume 4, Number 1, February 2013 pp.13-18

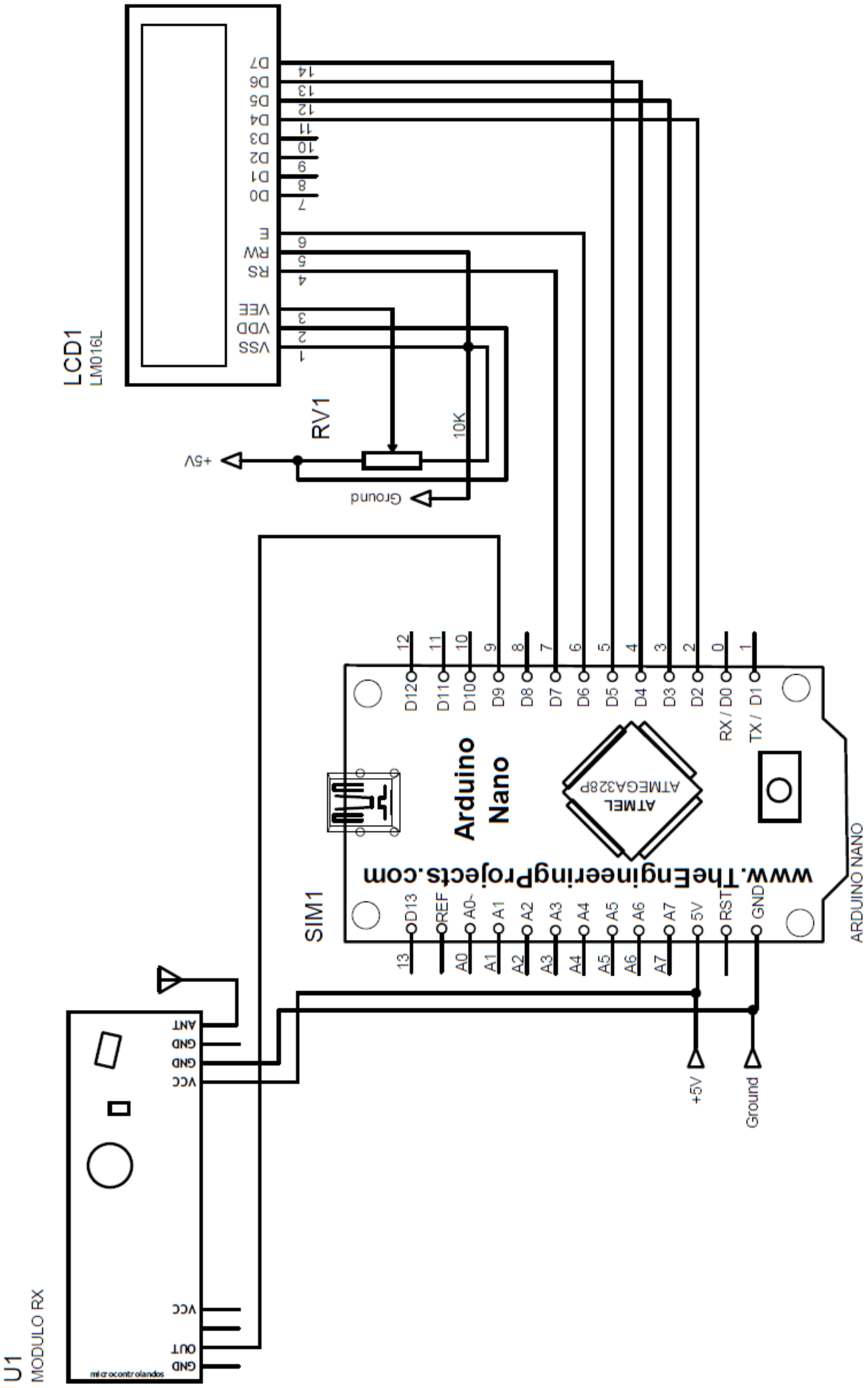
(9) Nograles, H. A. H., Agbay, C. P. D., Flores, I. S. L., Manuel, A. L., & Salonga, J. B. C. (2014, 6-8 May 2014). Low cost internet based wireless sensor network for air pollution monitoring using Zigbee module. Paper presented at the Digital Information and Communication Technology and it's Applications (DICTAP), 2014 Fourth International Conference on.

(10) Steven F. Barrett, “Arduino Microcontroller Processing For Everyone”, Published by Morgan & Claypool Publishers, 2nd Edition (18. Juni 2012)

D. AINEX 2017 COMPETITION CERTIFICATE

E. ELECTRICAL CIRCUIT DIAGRAM

Electrical Ciruit Diagram for Haze Monitoring Center



Electrical Circuit Diagram for Haze Monitoring Terminal