Early detection of LPG gas leakage based Wireless Sensor Networking

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Abstract. LPG gas is the main fuel used in households. These days LPG gas leak triggered an accident that resulted in huge losses, especially if the accident occurred within the dense housing. LPG gas leakage monitoring and early detection of a gas leak and a leak warning is needed to prevent more fatal accident. Wireless sensor networking is a technology that can be used to build a centralized monitoring system by using a microcontroller as the interface and control system. This research developed system device monitoring and early detection of gas leaks by utilizing gas sensors MQ-4 and AVR microcontroller family as control devices. The system is also equipped with XBee PRO S2B nirkable devices as the interface to the wireless networking system that is used to transmit sensor data from the detection point to the monitoring center equipped with a PC and software integrated Visual Basic. Gas leak alert is sent with the message formats through social networking Gtalk.

1 Introduction.

The use of LPG gas in Indonesia is increasing. This situation is due to the implementation of government conversion subsidy from kerosene to LPG. With the increasing number of LPG gas consumer, then the case of leakage and explosion of LPG gas cylinders are also more and more. Based on data from the Indonesian Consumers Foundation (YLKI) , as many as 70% of cases are caused gas explosion gas stove accessories that do not meet standards and the remaining 30% due to consumer behavior . Tools used to detect this already developed in several previous studies exist that use sms or by using the buzzer. This system has flaws in remote communication. One of which should be available a cellular device to send sms and cannot be monitored on line and in real time.

In designing these tools, to detect the presence or absence of gas and LPG used a gas sensor MQ-4, as a controller and data processor using a microcontroller. Results of data processed is displayed on the LCD. In addition, data is also transmitted using wireless. At the receiver the data will be stored in a database and can be monitored via computer. The system is also capable of sending information to the Mobile users in the event of leakage of LPG gas. Tool is also equipped with LED indicator lights and a buzzer which indicates that the gas is detected by the sensor implies more.

2 Early Detection of LPG Gas Leakage

LPG is a mixture of various elements derived from natural gas. By increasing pressure and decreasing temperature, the gas turns into a liquid. LPG components are predominantly propane (C_3H_8) and butane (C_4H_{10}). LPG also contains other light hydrocarbons in small amounts, such as ethane (C_2H_6) and pentane (C_5H_{12}). Wireless Sensor Network (WSN) is a wireless network consisting of multiple sensors (sensor nodes) are placed in different places. The sensors will detect the object and send data wirelessly to the gateway and then to the server.

Fraiwan et.all (2011) in their research proposed a wireless safety device for gas leakage detection. The device is intended for use in household safety where appliances and heaters that use natural gas and liquid petroleum gas (LPG) may be a source of risk. The system also can be used for other applications in the industry or plants that depend on LPG and natural gas in their operations. The system design consists of two main modules: the detection and transmission module, and the receiving module. The detection and transmitting module detects the change of gas concentration using a special sensing circuit built for this purpose. This module checks if a change in concentration of gas(es) has exceeded a certain pre-determined threshold. If the sensor detects a change in gas concentration, it activates and audiovisual alarm and sends a signal to the receiver module. The receiver module acts as a mobile alarm device to allow the mobility within the house premises. The system was tested using LPG and the alarm was activated as a result of change in concentration.

[5] in their research use a prototype of a Wireless Sensor Network (WSN) to monitor and locate gas leaks of a complex indoor environment. Specifically, a mobile node is moving inside a building to monitor any leakage of carbon dioxide (CO2), supporting and displaying the level and the location of the leakage. Throughout the demonstration, the technological advantages of cognitive networking along with multihop routing are explored.

[1] in their work a safe Coal Mine Monitoring system which replaces the traditional coal mine monitoring systems which tend to be wired network systems. This play an important role in coal mine safe production. With continuous enlarging of exploiting areas and extension of depth in coal mine, many laneways become monitoring blind areas, where are lots of hidden dangers. Moreover, it is inconvenient to lay cables which are expensive and consume time.

In order to solve the problems, we designed a coal mine safety monitoring system based on wireless sensor network, which can improve the level of monitoring production safety and reduce accident in the coal mine. Zigbee technology provides a direction for scientists who commit to solve the safety monitoring problems of coal mine. The purpose of this study is to propose a solution suitable to mine wireless communication, safety monitoring, give a proof to the further study.

2.1 Material of Early Detection of LPG Gas Leakage

2.1.1 Gas sensors MQ-4/MQ-6

MQ-4 gas sensor is a gas sensor has high sensitivity to methane, propane, and butane. Material of MQ-4 gas sensor is SnO2. Conductivity will rise in proportion to the increase in the concentration of the detected gas (Hanwei Electronics). Equivalent circuit of gas sensor MQ 4 is shown in Fig 1.
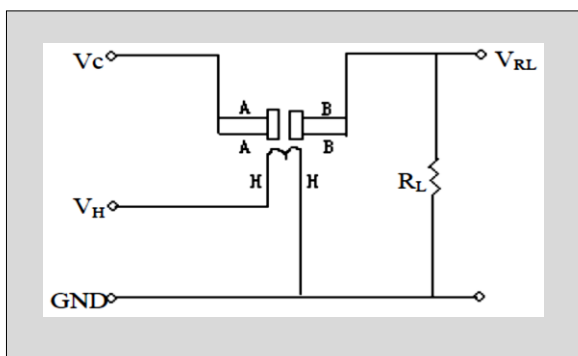

Fig 1. Equivalent circuit of gas sensor MQ-4

This sensor requires a supply voltage (VC) at 5 volts DC and voltage sensors are used for heating (VH). the output of the sensor MQ-4 is the change in the value of the sensor resistance (RS) contained between points A and B. The value of the sensor resistance MQ-4 will be converted into the output voltage by adding a series resistor RL. RS is resistant value can be obtained by using equation 1.

$$Rs = \frac{Vc}{V_{RL} - 1} \times RL \qquad (1)$$

LPG gas concentration can be obtained from ratio the RS and R0 with R0 is the resistance of reference which can be calculated by looking at the characteristics of the sensor are shown in figure 2.
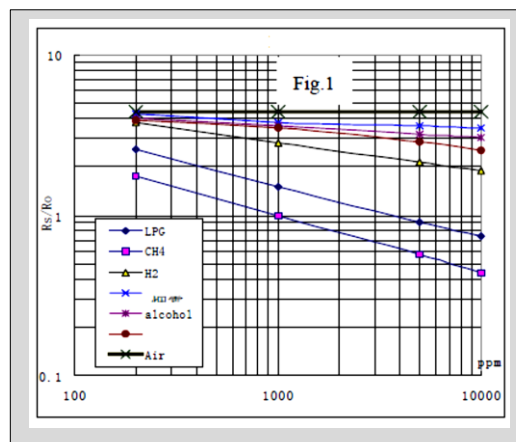

Fig 2. Characteristic of sensor MQ-4

2.1.2 AVR microcontroller family

ATMega8 AVR microcontroller CMOS 8-bit AVR RISC architecture which has 8K bytes of In-System Programmable Flash. Microcontroller with low power consumption is capable of executing instructions at maximum speed 16MIPS at 16MHz frequency. ATMega8 has a 28 pin, each pin has its different functions both as a port and other functions.

2.1.3 XBee PRO S2B

XBee PRO S2B is a RF module made by Digi International to meet the ZigBee standard, a technology with low data rate (Low Data Rate), and low cost (Low Cost). XBee PRO S2B module is easy to use for transceiver radio waves at a frequency of 2.4 GHz ISM band. The output power and frequency channel can be easily programmed through the X-CTU interface.

Addressing is used to distinguish between the XBee PRO S2B with other XBee PRO S2B and prevent duplication of data packets. Each module is XBee PRO S2B has a source address to prevent non - duplicate messages are not considered a duplicate message. XBee PRO S2B has two basic forms of addressing, namely Broadcast and Unicast. Broadcast message is a message that will be received by all modules that have a PAN ID (Personal Area Network) is the same.

2.1.4 Google Talk Application

Google Talk (GTalk) is a web-based application service from Google that created as a means to communicate via instant messaging and VoIP.

Google Talk is provided free of charge and can be downloaded and accessed through Google. Google Talk service can only be used if already have an account on Google. Existing instant messaging between the Google Talk servers and its clients uses an open protocol, and XMPP which allows users to other XMPP clients to communicate with Google Talk users [2]. Meanwhile, Google Talk VoIP based on the Jingle protocol. The technology used in the Google server network cannot be known by the public. Google Talk software is available for BlackBerry, iPhone, and T-Mobile G1.

3 Systems and Methods of Research

Wireless sensor network applications for the early detection of LPG gas leakage includes hardware design and software design. The design of the system is divided into two parts, namely the design of the sender (transmitter) and receiver design part (receiver). Block diagram of the system design shown on fig 3.
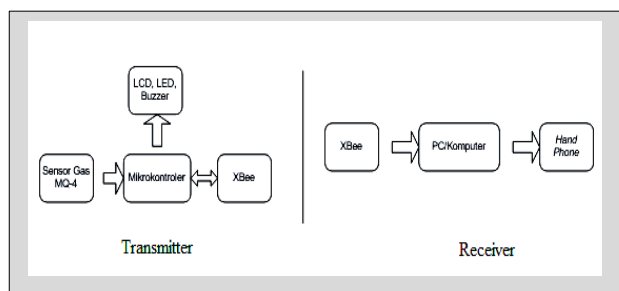

Fig 3. Block Diagram Design System

From the block diagram of Figure 3 can be explained how the system as a whole. Gas sensor will detect the presence of LPG gas in a room. The voltage value will then be converted into digital data by ADC (Analog to Digital Converter) on the microcontroller. Then the obtained data will be processed by the microcontroller and the results will be displayed on the LCD. The data is displayed on the LCD is a concentration of LPG gas.

LPG gas monitoring data is also transmitted wirelessly from the transmitter to the receiver. The devices used for the delivery of data is 2.4 GHz XBee PRO S2B. Once the data is received by the receiver and then the data is stored in a database on the server PC, the user interface of the software used in visual basic 2008. If the system detects a gas leak has occurred LPG then the information will also be sent to mobile home owners or users using GTalk application. So, when the LPG gas leak in a room, the system will provide early warning buzzer or through the LCD, PC servers, and mobile users.

4 Results and Discussion

4.1 Testing to Determine the Concentration of a Gas Sensor LPG

Testing done by varying the concentration of LPG gas to be detected by the sensor MQ 4. Values obtained from this test sensor resistance (R_S) which will be used to determine the level of leakage in LPG. To calibrate the sensor, then find the value of R0 as the reference ratio between RS and R0 as a determinant of the value of PPM. From several testing RS values obtained as shown in Table 1.

Table 1. R_S value for gas sensor MQ 4

Voltage (V_{rl})	Rs (Ω)
2.35	74074.07
2.63	61349.69
2.77	56497.18
3.01	49751.24
3.27	44052.86

4.2 Testing Serial Communication Wirelessly with XBee PRO S2B

The test is performed to test the wireless communication between the transmitter and receiver. This test uses the XBee PRO S2B for each sender and receiver, the minimum system atmega 8 at the sender, as a voltage converter IC MAX232 RS232, USB to serial cable to connect the receiver to a laptop, as well as the X-CTU program. The results of testing the communication system is shown in Fig 4.
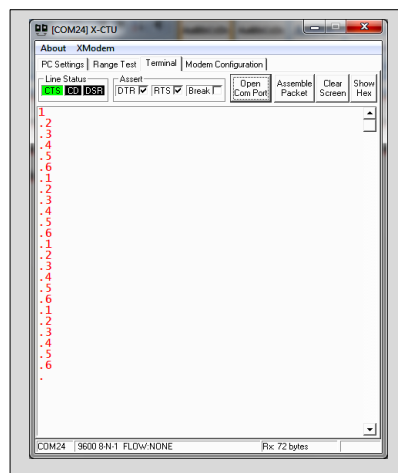

Fig 4. The results of testing the communication system

4.3 Testing the monitoring system with visual basic

Testing is done by observation data and graphs presented on the monitoring system using visual basic. The test results are shown in Fig 5.

4.4 Testing Software for Sending Messages to Gtalk Application

Software testing is performed to determine whether the software has been made appropriate design, which can send a message to the GTalk app. Software is created using the Java programming language. As a GUI (Graphical User Interface)

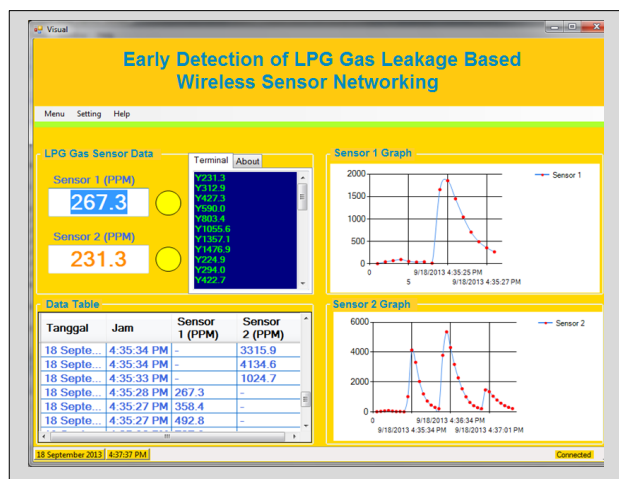using NetBeans IDE 7.3.1. test results are shown in Fig 6.
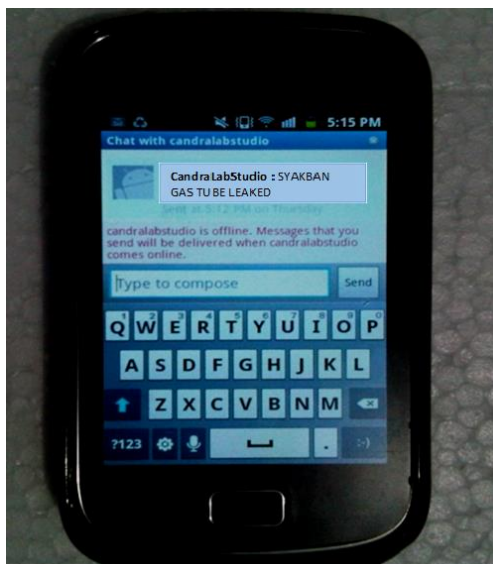

Fig 5. Monitoring system using visual basic

Fig 5. Message gas leak on Gtalk

5 Conclusion

Designing early detection of LPG gas leakage based wireless sensor network has been implemented properly in accordance with the system design. The output of the gas sensor MQ-4 amendments linear and proportional to the change in the input side, evidenced by the line equation $y = 1.000x + 0.004$ with a 3.46% error. The system interface can display and store data with good gas sensors and displays graphs for monitoring is done. Warning message about LPG cylinder leakage through GTalk application can be run in accordance with desired.

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