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Microcontroller-Based Gas Leak Detector Prototype Design

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ABSTRACT

The majority of Indonesia's population has used LPG gas for various activities in daily life. However, often the use of LPG provides a fairly high risk of LPG gas leakage. Identification of gas leaks often goes undetected. The MQ-7 gas sensor is used to detect indoor gas leaks. Arduino uno R3 is used as a microcontroller for the system to run. To facilitate the identification of LPG gas leaks, the tool designed can provide alarm notifications from buzzers and LCDs that display gas values and red LEDs that state LPG gas leaks. Thus leaks can be handled immediately with the right steps before a fire or explosion occurs.

Keywords: *LPG Gas Leak, Microcontroller, MQ-7*

1 Introduction

Increased access to environmentally friendly cooking fuels such as liquefied fuel gas (LPG) has become a guideline for energy policy in low- and middle-income countries (Nuño Martínez et al., 2020). The Indonesian government is working to increase modern energy consumption by increasing the distribution of subsidized and non-subsidized LPG in Indonesia in the past decade (Hartono et al., 2020). From the last two years, the increase in LPG use in 2021 was 83.36% to 87.12% in 2022 (*Household Gas Use Ratio, 2021-2022*, 2023). The data states that the majority of Indonesians already use LPG in their daily lives for various needs, such as industrial needs, households, and even transportation because of low prices and more effective use (Karmilawati dwi Rahayu et al., 2023; Nur Alfan & Ramadhan, 2022). The use of LPG often causes fires or explosions that cause losses. The causes of LPG cylinder leaks include the quality of rubber seals that do not meet standards, leaks in the valve system, imperfections in the gas cylinder itself(Yulia & Elfizon, 2022). During the first two months of 2023, there have been at least eight explosions with 17 victims in Jakarta triggered by LPG cylinder leaks (Salasah, 2023)(Saktioto et al., 2021). Explosions and fires often occur because people cannot detect leaks in LPG cylinders. By identifying the occurrence of LPG leaks can reduce the risk of fire. After identification of LPG leaks, preventive measures can be taken before roots or explosions occur, such as removing the regulator to stop gas from escaping from LPG cylinders (Darnoto et al., 2023).

Fires caused by LPG cylinder explosions can be prevented by providing security in the area around the use of LPG, one of which is around the LPG regulator where there are often leaks in the area. Technological developments at this time trigger to innovate to create tools that can prevent disasters, one of which is a fire due to a gas leak (Praja Dwitama et al., 2021). One technology that can be applied is utilizing the MQ-7 sensor and the use of microcontrollers. Some research by utilizing MQ sensors and Arduino Uno microcontrollers. Among them are research conducted by Fauziyah using the MQ-6 sensor to detect gas leaks and a microcontroller to turn on the buzzer (Fauziyah et al., 2020).

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The problem in this research is how to make LPG leak detection devices with MQ-7 sensors and Arduino Uno microcontrollers. This research aims to create an LPG gas leak detection tool using the MQ-7 sensor based on the Arduino Uno microcontroller which is used to help minimize the occurrence of disasters due to LPG leaks(Saktioto et al., 2020)(Irawan et al., 2023).

2 Methodologists

The method used in this study is the development method *Waterfall*. Method *Waterfall* is one of the development methods that is often used in the development of information systems or software. Method *waterfall* implemented with a systematic and sequential approach. The stages of this method begin with planning to the management stage which is carried out in stages (Wahid Abdul, 2020). The waterfall method can be seen in Figure 1.

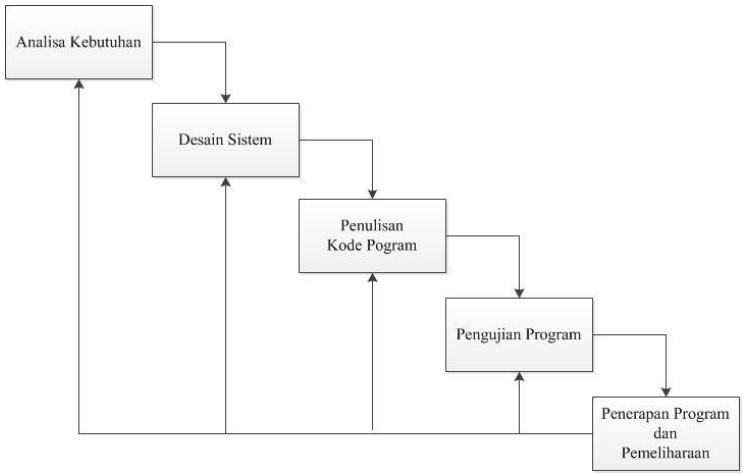

Figure 1: Method Flow *Waterfall (Waterfall System Development Method, 2013)*

The flow in creating a system in this study is:

1. Needs analysis, conducting the collection of tools and components necessary in research. The tools and components needed in building this LPG gas leak detector system are MQ-7 sensors, Arduino uno, LED lights, buzzers, and LCDs.
2. System design, designing the stages of implementation of needs analysis, namely designing block diagrams, flowcharts and tool display design.
3. Writing program code, after the implementation of system design, it is continued with making programming code or coding. The programming code uses C ++ code and the application used is the Arduino IDE.
4. Testing, the project was carried out testing the basic functions of the system design, where testing the sensitivity level of the MQ-7 sensor was carried out.
5. Implementation and Maintenance stage, the project implementation process is carried out by applying the product directly. Maintenance process or *maintenance* of each function of the LPG gas leak detector is carried out.

2.1 Diagram

A block diagram is a description of how the tool works as a whole from input, process to output. The block diagram illustrates the path relationships between the blocks, and each block contains a main component and a supporting component of the system. The block diagram of the microcontroller designed tool can be seen in Figure 2.

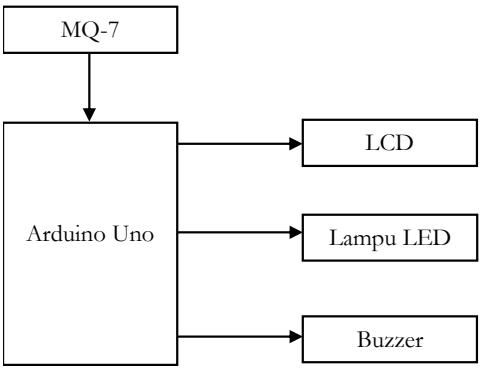

Figure 2 : LPG Leak Detector System Block Diagram

Based on the block diagram in Figure 2, the function of each block is explained as follows:

- Arduino microcontrollers are used to control all components, namely input components and output components.
- The MQ-7 sensor is used to measure gas levels.
- LCD I2C 16x2 is used as a monitor that will display gas values.
- LED lights are used to provide visual notifications.
- The buzzer is used to provide notifications in the form of sound.

2.2 Network Scheme

The circuit scheme describes the relationship between several components and sensors where the components and sensors function as the constituents of the control system (Handoko, 2017). The circuit schematic design drawing is shown in Figure 3.

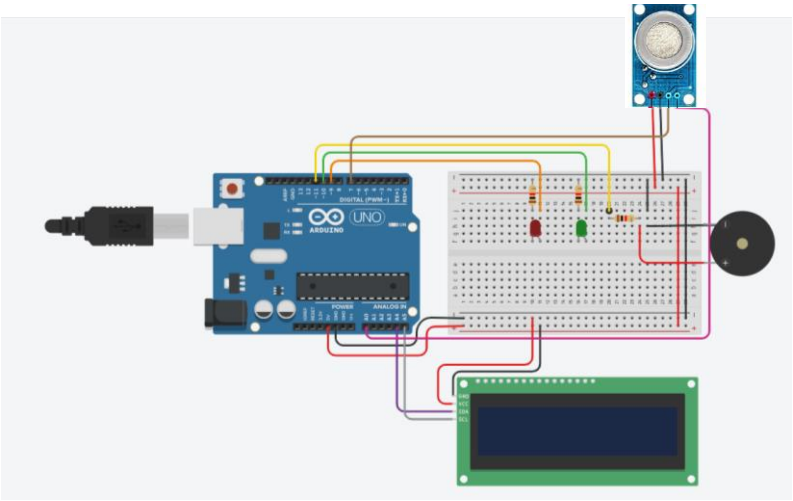

Figure 3: Component Installation Network Scheme

2.3 Flowchart Diagram Sistem

A flowchart is a flowchart that illustrates how a system processes into clear process specifications. The flowchart in the design of the LPG gas leak detector system can be seen in figure 4.

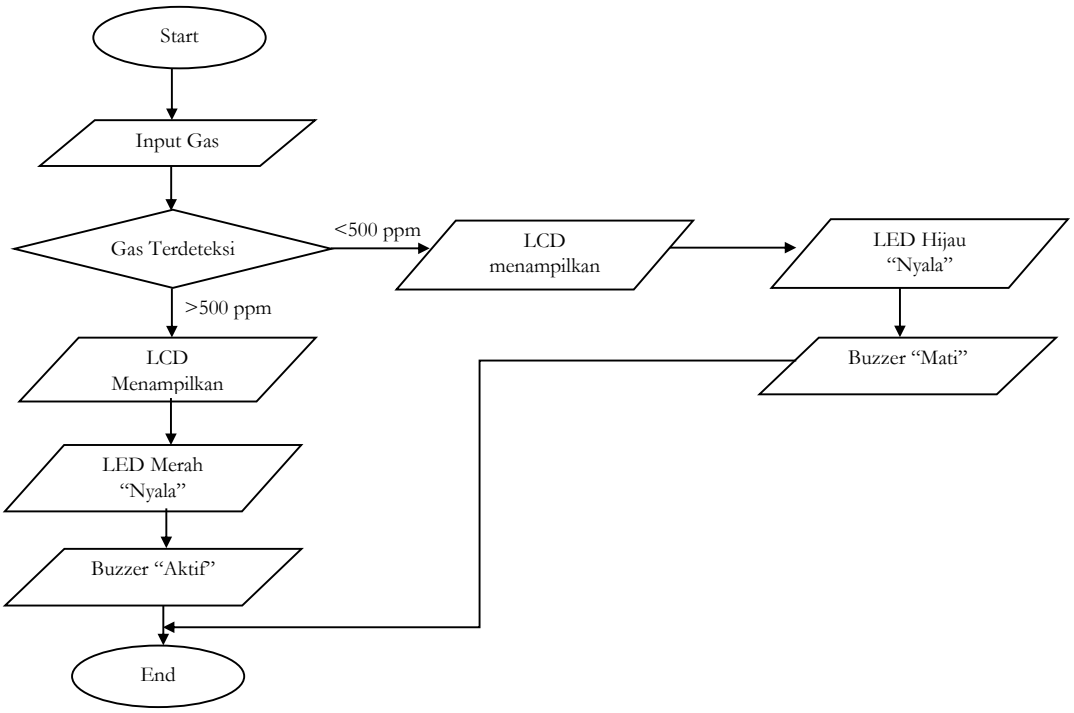

Figure 4: Flowchart Sistem

2.4 Tools and Materials

Microcontrols Arduino Uno

Arduino Uno is an open source electronic circuit board. Arduino itself contains microcontrollers, such as the Atmel ATmega328p or ATmega168, and relies on these microcontrollers in prototype development and projects(Handoko, 2017). Arduino Uno R3 has 14 digital input or output pins, 6 analog input pins using a 16 MHz crystal consisting of pins A0 to A5, power jack, ICSP header, USB connection and reset button. The analog pin in the Arduino Uno R3 has a reference analog voltage of 5 volts. The analog pins in the Arduino Uno R3 have a feature that can convert incoming analog signals into easy-to-measure digital values. Analog pins can recognize signals in the range of voltage values of 0 volts-5 volts. While digital pins can only recognize 0 volt signals as LOW values and 5 volts as HIGH values. Analog pins are very useful when measuring something from a sensor and using that input value for other purposes. The shape of the Arduino Uno R3 board can be seen in Figure 5.

Figure 5: Arduino uno R3

MQ-7 Sensor Module

The MQ-7 sensor is a sensor that functions to detect the value of combustible gases. Sensors are used to detect a wide range of gases containing carbon monoxide and are low-cost sensors for a wide range of applications. The MQ-7 gas sensor uses lead dioxide (SnO2) material with lower conductivity properties in clean air. Low temperatures at 1.5V heating are used to detect methane gas using the high temperature cycle detection method. Increasing the concentration of methane gas in the air will increase conductivity,

under high temperature conditions at 5.0V heating will clean up wild gas adsorbed at low temperatures. The output signal corresponding to the gas concentration is obtained from the conversion of conductivity changes in a simple circuit. The MQ-7 gas sensor is very sensitive to methane gas. The shape of the MQ-7 sensor module can be seen in Figure 6.

Figure 6 : MQ-7 Sensor Module

LCD I2C

LCD is a display medium that produces a good and quite a lot of character display. The 16×2 LCD can display 32 characters, 16 characters on the top line and 16 characters on the bottom line. 16×2 LCDs generally use 16 pins as controls, so it is necessary to use special drivers so that the LCD can be controlled with the I2C line. Through I2C, the LCD can be controlled using only 2 pins, namely SDA pin and SCL pin. The shape of the I2C LCD can be seen in Figure 7.

Figure 7 : LCD I2C

Breadboard

Breadboard is a board used to assemble electronics that are used as electronic circuits without the need to solder. The use of breadboard or projectboard can minimize errors in the circuit. Figure 8 shows the shape of the breadboard:

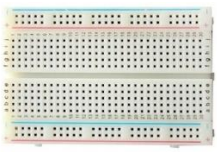

Figure 8: Breadboard

LED

LED is a component that can emit light. It is a type of diode, which converts electrical energy into light energy. There are many variations of LED colors, the shape of the LED can be seen in Figure 9.

Figure 9 : LED

5V Buzzer

A buzzer is an electronic component that converts electrical vibrations into sound vibrations. Buzzers are used as alarms. The shape of the buzzer can be seen in Figure 10.

Figure 10: Buzzer

Resistor

The recitor is a component that provides obstacles to limit and regulate electric current. The shape of the resistor can be seen in Figure 11.

Figure 11 : Resistor

Cable Jumper

Jumper cable is an electrical circuit connecting cable that has a connector pin at the end that can be used to connect two components. The shape of the jumper cable can be seen in Figure 12.

Figure 12 : Cable Jumper

3 Results and Discussion

The research conducted produces LPG gas detectors in the event of a leak that can be installed in households. With a gas leak, if it meets sufficient levels it will cause a fire or explosion. Then this tool can be used as a detection of gas leaks before high levels.

3.1 System Installation

This stage is the process of assembling or installing the system, unifying the Arduino Uno R3 with MQ-7 sensors, 16x2 I2C LCD, red LEDs and green LEDs, and buzzers. The system assembly drawings are shown in Figure 13.

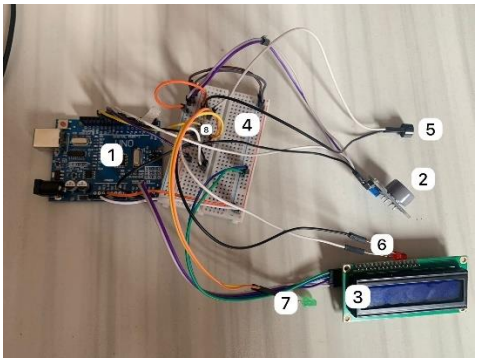

Figure 13: System Component Reconciliation

The communal assembly of the system on figure 13 uses the following materials:

1. Arduino Uno R3
2. Sensor MQ-7
3. LCD I2C 16x2
4. Breadboard
5. Buzzer
6. Red LED
7. Green LED
8. Resistor

3.2 System Program Encoding

The next stage after system assembly is system programming by providing some instructions in the circuit. Encoding system programs using Arduino IDE software. The following is a fragment of the instruction code on the LPG leak detector system addressed in figure 14.

Figure 14: LPG Gas Leak Detector System Program Code

3.3 Tool Testing

The success of a system is declared after testing the tool. This test uses a method of testing the sensitivity level of the MQ-7 sensor to combustible gases, this test uses gas from a lighter. Figures 15 and 16 show a gas leak detector system test.

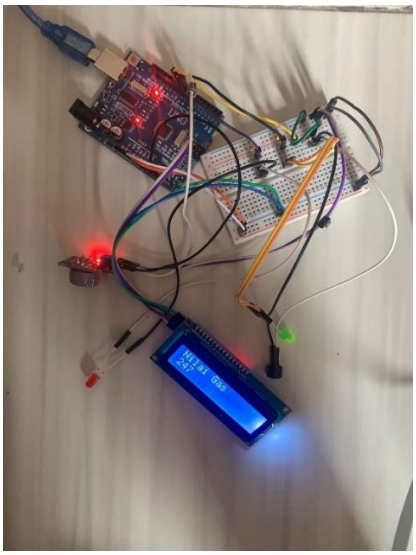

Figure 15 : Testing in room gas

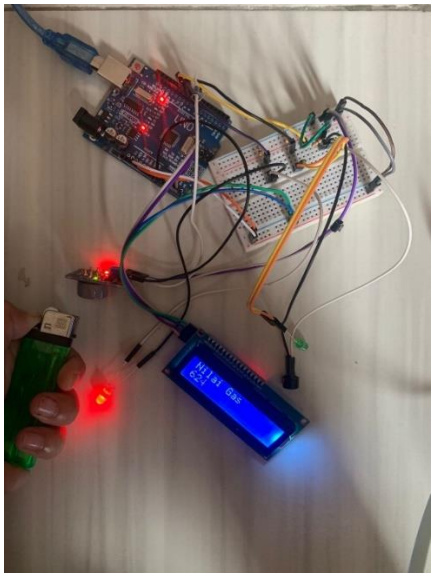

Figure 16 : Tests using combustible gases from matches

Figures 15 and 16 above show the test results of all components contained in the system. The I2C 16x2 LCD test successfully displayed gas values or gas levels of carbon dioxide and carbon monoxide in the air captured by the MQ-7 sensor. If the level is below the specified threshold of <500ppm, the green LED will light up and the buzzer is off. If the level exceeds the specified maximum threshold of > 500 ppm, the red LED will light up and the Buzzer will be active.

Figure 17 : LPG Gas Leak Detector Prototype

The following is a table of the condition of the work results of the tool after testing:

Table 1: System Working Conditions

Condition	MQ-7	Output	
		Buzzer	LED
1	Does not detect or detect Gas <500 ppm	Die	Green
2	Detects Gas <500 ppm	Active	Red

Table 2: System Working Conditions

No	Component	Result

		Work	Not Working
1	Arduino Uno R3	✓	-
2	MQ-7	✓	-
3	LCD	✓	-
4	Red LED	✓	-
5	Green LED	✓	-
6	Buzzer	✓	-

Table 3 : System Test Results

No	Kadar/Nilai Gas (ppm)	Condition	
		LED	Buzzer
1	247	Green	Off
2	360	Green	Off
3	405	Green	Off
4	517	Red	Active
5	596	Red	Active
6	624	Red	Active
7	705	Red	Active
8	780	Red	Active

3.4 System Performance Analysis Results

Based on the test results shown in tables 1 and 3, the performance of the LPG gas leak detector system is analyzed as follows:

1. When gas monoxide is detected by the system with an MQ-7 sensor with a value or gas content of 0 ppm to 500 ppm, the system will turn on the green LED and the buzzer is disabled.
2. When gas monoxide is detected by a system with an MQ-7 sensor with a gas value or content of > 500 ppm, the system will turn on the red LED and the buzzer is active. So this system will provide sound notifications.

The disadvantage of this system is that it is not yet IoT-based so that if the homeowner is not at the location then he cannot receive notifications from this tool.

4 Conclusion

Based on the research that has been carried out, it can be concluded that this system can identify gas leaks through the MQ-7 sensor and show a red LED indicator and send a warning notification in the form of a sound from the buzzer. With this system, it can make it easier to detect LPG gas leaks. So as to minimize the risk of fire or explosion.

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