Design of Arduino-based LPG Gas Leak Detection Tool using MQ-6 Sensor

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Abstract

LPG (Liquefied Petroleum Gas) is a natural resource that has increased yearly consumption. LPG gas is used almost every time for human life in the household and industry sectors. LPG gas, besides being cheap, is also easier to use. However, the increasing use of LPG gas also increases the risk of fire or gas collection caused by LPG gas leaks. Therefore, a tool is needed to detect LPG gas leaks. So an LPG gas leak detector was made using the MQ-6 sensor, which can detect LPG gas leaks, and using a blower fan to overcome the collection of gas levels around LPG gas cylinders, using a buzzer as an alarm, using a servo to turn off the electricity so that an explosion does not occur, and use spray foam to spray onto the tube and stove if the blower cannot handle the LPG gas leak. Overall, the design components are controlled by Arduino Uno R3. This testing process takes an average of 9.56 seconds. If it is less than 9.56 seconds, then only one action is enough: the blower fan, active buzzer, and pump 1. If it is more than 9.56 seconds, the second action will be continued: spraying foam and turning off the electricity. On the other hand, there is an opportunity to bring this tool to commercial. Many households need this tool to save their house from fire threats. Finally, this tool can be a development tool for solving an incident from gas and will be a best-selling tool.

Keywords: LPG Gas; MQ-6 Sensors; Arduino Uno R3; Leak Detection; Automation

Introduction

Liquefied Petroleum Gas (LPG) is a natural resource that experiences an annual increase in consumption. LPG gas is almost always used for human life in the household and industrial sectors. Apart from being cheap, LPG gas is also easier to use. However, the increasing use of LPG gas also increases the risk of fire or gas accumulation caused by gas leaks (Nurnaningsih, 2018).

Delays in detecting LPG gas leaks can trigger fires or explosions. This fire or explosion occurs because the leaking gas is trapped and accumulates in a closed room. So, when there is a spark, lighter, or static electricity, it automatically causes a fire or explosion. This is due to the gas, air (oxygen), and heat mixture. That is what is called the fire triangle. To burn or explode, LPG must meet these three elements.

Based on the description above, an LPG gas leak detection device is needed to minimize the occurrence of fires or gas accumulation. Detecting LPG gas leaks can use Arduino Uno R3, Blower, and MQ-6 Sensor. The Arduino Uno R3 serves as the controller system, the blower is tasked with throwing gas out of the kitchen or LPG gas area, and the MQ-6 Sensor is tasked with detecting LPG gas leaks.

On the other hand, there is an opportunity to bring this tool to commercial. Many households need this tool to save their house from fire threats. Finally, this tool can be a development tool for solving an incident from gas and will be a best-selling tool.

Based on the problems above, this research intends to create a system with the research idea "Design of An Arduino-based LPG Gas Leak Detection Tool Using MQ-6 Sensor".

Literature Review

Tool design is carried out before starting to assemble the tool. The aim of designing a tool is so that the tool you want to make can be appropriately assembled without any shortcomings. The design stage consists of several stages: designing the block diagram and the entire tool.

Block Diagrams

Block diagrams are used to show the main parts when creating a new system or improving a system. Figure 1 is a block diagram of the tool.

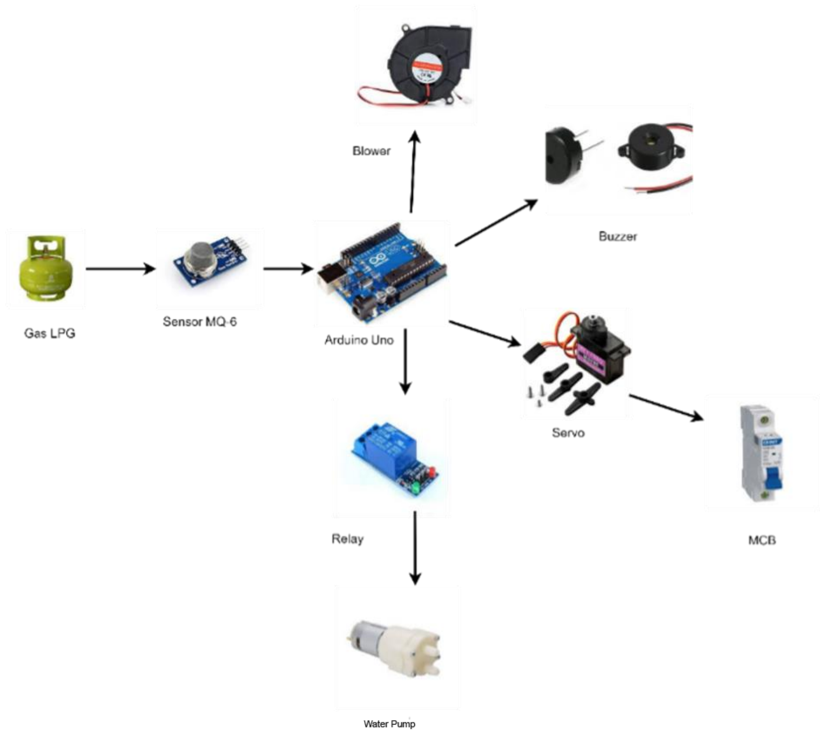

Figure 1. Block Diagram of Tool Work

Tool Placement Sketch Design

The design for the prototype room model used in this research is 21 cm long, 21 cm wide, and 15 cm high. In this room are two sensors above the regulator and the LPG gas. The sensor functions to detect LPG gas leaks in the box at 3 cm. The following is a design sketch of tool placement in Figure 2.

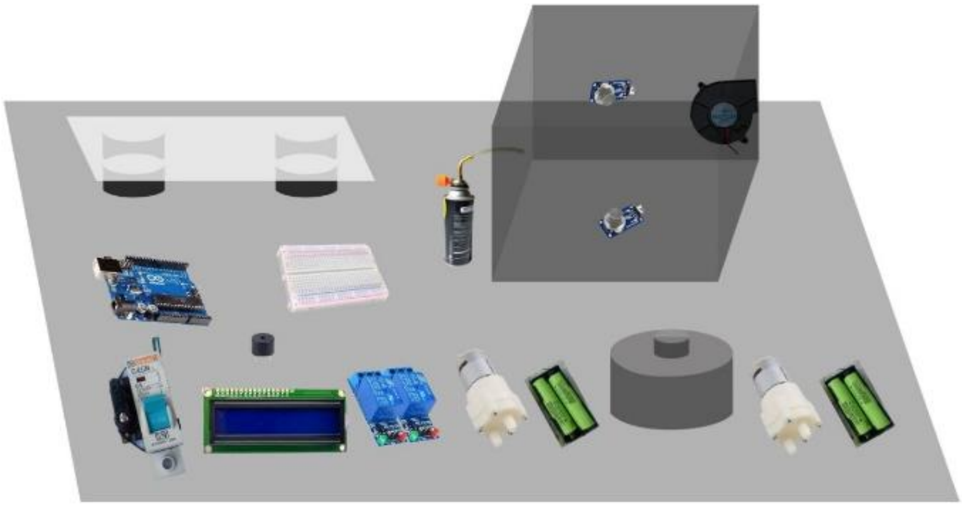

Figure 2. Tool Placement Sketch Design

a) Arduino Uno R3
Arduino Uno R3 is a microcontroller development board based on the ATmega328P chip. Arduino Uno has 14 digital input/output pins (or usually written I/O, of which 14 pins can be used as PWM output, including pins 0 to 13), six analog input pins, using a 16 MHz crystal, including pins A0 to A5, USB connection, a power jack, ICSP header and reset button. This is all needed to support a microcontroller circuit (Juliantoro et al., 2022).

b) MQ-6 sensors
The MQ-6 sensor in Figure 3 is a gas sensor suitable for detecting LPG (Liquefied Petroleum Gas) gas, it can detect LPG gas and includes gas consisting of LPG gas, namely propane and butane gas. This sensor can detect gas at concentrations in the air between 200 to 10000 ppm. This sensor has high sensitivity and fast response time. The sensor output is an analog resistance. The circuit of this sensor is elementary. This sensor requires a voltage of 5 V, adds load resistance, and connects the output to the ADC (Adiapasa et al., 2022).

c) Servo Motor
A servo motor is a device or rotary actuator (motor) designed with a closed-loop feedback control system (servo) to be set up or adjusted to determine and ensure the angular position of the motor output shaft. A servo motor consists of a DC motor, a series of gears, a control circuit, and a potentiometer.

d) Relays
A relay is an electromechanical component consisting of an electromagnet (coil) and a mechanical (a set of switch contacts). The relay function assists in disconnecting or connecting electric current automatically.

e) LCD I2C (Liquid Crystal Display)
LCD I2C is an LCD layer module that is compatible with Arduino. This module consists of an LCD layer and an integrated I2C controller, which allows users to connect to the Arduino with just the SDA (Serial Data) and SCL (Serial Clock) pins. To use it requires additional libraries on the Arduino idea, such as "LiquidCrystal_I2C". With this library, users can quickly display text, adjust the position of the text, and control other features.

f) Water pump
The water pump is a tool that can help control the water content on the ground surface. The way this water pump works is that when there is excessive water, the water pump will suck up the water and then help drain it to the water reservoir provided.

g) Buzzers
A buzzer is an electronic component that converts current vibrations into sound vibrations. The buzzer has an electromagnetic coil attached to the diaphragm. When the coil is

electrified, it will produce a magnetic field. Then, the coil will be attracted in or out, depending on the current's direction and the magnet's polarity. Because the coil is mounted on the diaphragm, every movement will move the diaphragm back and forth, causing the air to vibrate, producing sound.

h) Blower Fan
DC 12V blower fan is designed to operate with 12-volt DC (direct current) power. Blower fans are typically used in applications that require strong airflow, such as electronic cooling, ventilation, or heating systems.

Research Method

Based on literature studies from several journals, a safe limit for LPG gas levels < 200 ppm is applied, and when LPG gas levels are > 200 ppm, the tool will function. Parts per million or Parts per million (PPM) is a ratio used to describe the amount of contaminant or concentration contained in a substance. LPG gas has hazardous properties because it is flammable and explosive; it is not poisonous, but if inhaled more than 1,000 ppm or 0.1% (100%=1,000,000 ppm), it will cause drowsiness, dreams, and death (Silalahi et al., 2022).

The planned system is composed of a combination of hardware and software subsystems. The hardware used to make the prototype is Arduino Uno R3, MQ-6 sensor, blower fan, electric meter, spray foam, and buzzer. When the sensor detects a gas leak, the Arduino Uno R3 as a microcontroller will process the data sent by the sensor for LPG gas levels > 200 ppm, then the microcontroller will execute the command to activate the blower fan and turn on the buzzer. If the LPG gas level continues to increase to > 400 ppm, the program will activate to turn off the electricity meter and spray foam.

Result

This research results in the design of an Arduino-based LPG gas leak detection device using an MQ-6 sensor to detect gas levels around LPG gas. The following is a view of the tool designed in Figure 3.

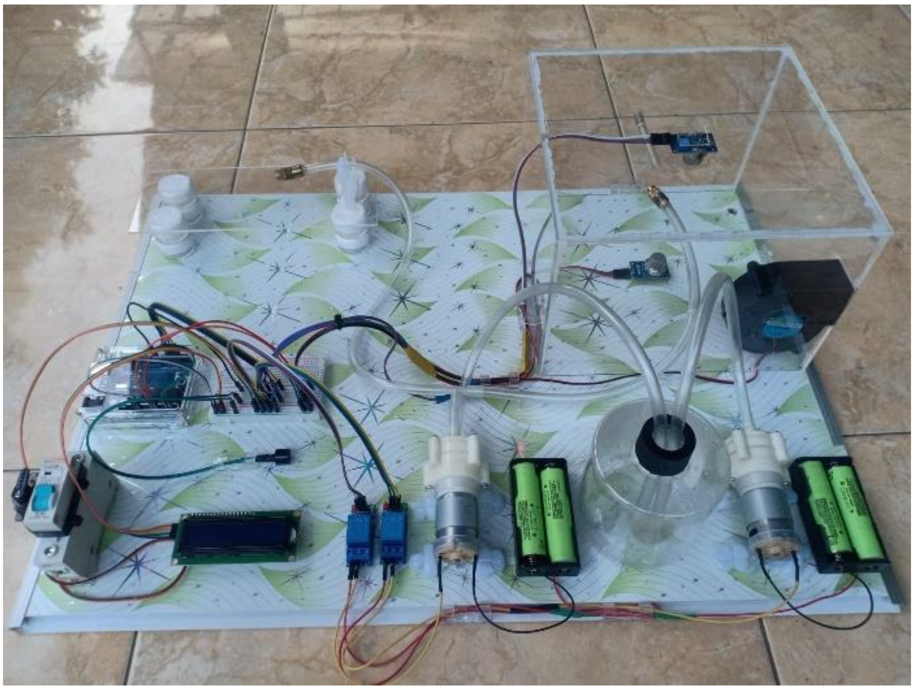

Figure 3. LPG Gas Leak Detection Equipment

The flow diagram is the work process of an Arduino-based water control automation tool. The flow diagram can be seen in Figure 4.

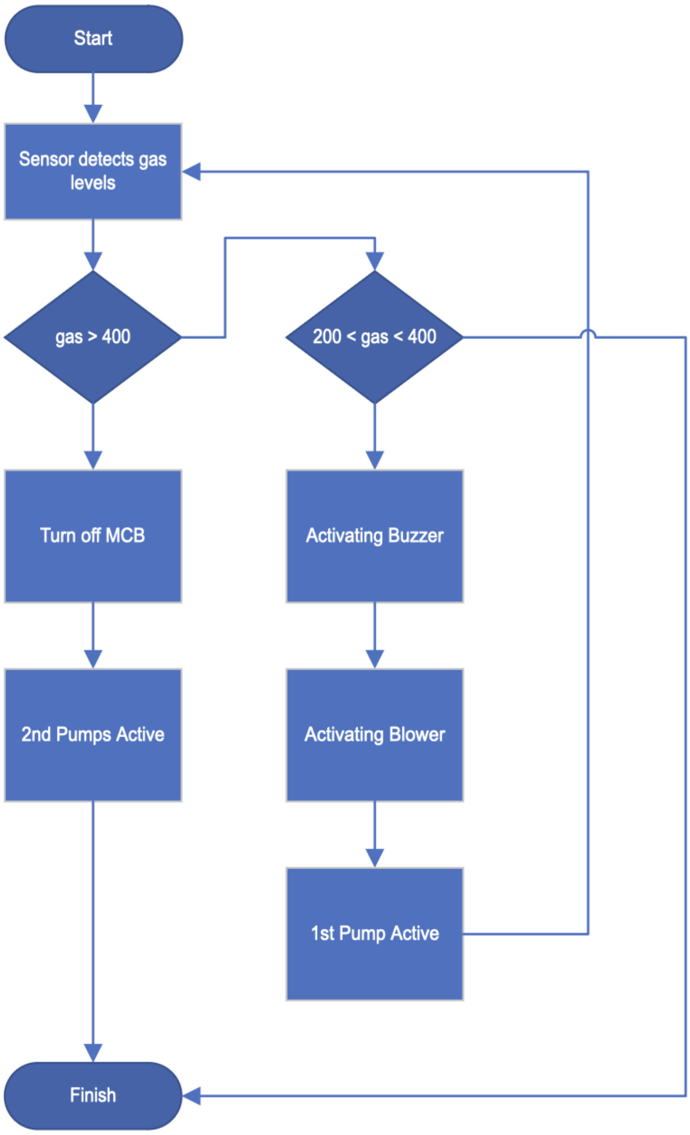

Figure 4. Workflow Diagram

The explanation of the workflow diagram is in Figure 4.

a. The test is carried out when gas is leaked towards the sensor to detect the gas level.
b. After obtaining the gas level, the value is displayed on the LCD so that the condition of the occurring leak can be monitored.
c. In this test, when the gas level exceeds > 200 ppm, the buzzer turns on, 1st pump turns on, and the blower turns on.
d. If the gas level exceeds the gas level > 400 ppm, pump two will start, and the servo will also start.

Tool Testing

The test carried out in this research was to test the length of time the blower fan was on to reduce gas levels and the ppm value. In this test, the researchers carried out several experiments to find out how long it takes for the blower fan to reduce the ppm value, as seen in Table 1.

Based on the results of the implementation and testing that has been carried out, the LPG gas leak detection device can be designed as expected. Arduino can run well; when the value is > 200 ppm, the buzzer will turn on, 1st pump will also turn on to inflate the soap so that it can foam, and the blower will also turn on to remove gas levels from the space around the LPG cylinder. If the sensor detects gas levels > 400 ppm, 2nd pump will turn on to spray foam, and the servo will turn off the electricity meter. The MQ-6 sensor can detect gas levels when a leak occurs. However, the sensor reading could not reach 0 ppm when there was no leak after several attempts were made, which previously reached 0 ppm. Because the gas in the tube is in liquid form, when it is leaked, the gas will spray, but some will still come out in liquid form, and the liquid will stick to the sensor. So, the sensor will continue to read gas levels at 26 ppm to 29 ppm.

Based on Table 1, researchers can conclude that when a leak occurs from 200 ppm to 400 ppm, the blower will turn on to reduce the gas levels in the room. If the blower is only on for less than 9.56 seconds, then the blower action alone is enough to overcome the leak that occurs. However, when a leak occurs from 200 ppm to 400 ppm, and if within 9.56 seconds, the blower is still unable to handle it, it will continue with the second action. Namely, the pump will turn on to spray foam, and the servo will turn on to turn off the Miniature Circuit Breaker (MCB).

Table 1. Test results for the duration of action of the tool

No	1st Sensor >200 ppm	2nd Sensor >200 ppm	< 200 ppm	Time
1	250 ppm	337 ppm	106 ppm	5.57 Sec
2	396 ppm	369 ppm	54 ppm	5.31 Sec
3	368 ppm	356 ppm	71 ppm	6.50 Sec
4	200 ppm	375 ppm	164 ppm	4.41 Sec
5	219 ppm	-	113 ppm	2.50 Sec
6	289 ppm	-	191 ppm	3.21 Sec
7	245 ppm	-	149 ppm	2.43 Sec
8	410 ppm	-	43 ppm	36.89 Sec
9	282 ppm	-	112 ppm	2.80 Sec
10	216 ppm	-	116 ppm	2.63 Sec
11	383 ppm	450 ppm	42 ppm	39.65 Sec
12	273 ppm	341 ppm	179 ppm	4.48 Sec
13	252 ppm	307 ppm	77 ppm	5.84 Sec
14	333 ppm	370 ppm	75 ppm	5.51 Sec
15	340 ppm	423 ppm	52 ppm	35.30 Sec
16	200 ppm	343 ppm	146 ppm	11.65 Sec
17	309 ppm	379 ppm	103 ppm	9.18 Sec
18	375 ppm	346 ppm	83 ppm	5.69 Sec
19	349 ppm	333 ppm	76 ppm	5.77 Sec
20	322 ppm	312 ppm	77 ppm	5.33 Sec
21	288 ppm	333 ppm	72 ppm	5.82 Sec
22	310 ppm	-	185 ppm	3.82 Sec
Average	300 ppm	358 ppm	104 ppm	9.56 Sec

Conclusion

All the tools worked as desired based on the design and testing results, but the sensor could not detect 0 ppm again after several trials. The lowest levels read by the sensor after several experiments were in the range of 26 – 43 ppm. When the tool is used or turned on, the gas level will immediately be detected at around 70 – 180 ppm. After a while, the gas levels will drop back to normal. Because in the room, there are still residual gas levels from the previous experiment. Research carried out with the MQ-6 sensor has proven effective in detecting LPG gas leaks because the sensor has high sensitivity to LPG gas and can respond quickly to gas leaks. This detection tool can potentially increase the safety of using LPG gas in households, commercial or industrial settings. Detecting LPG gas leaks early can provide adequate preventive measures to minimize or reduce the risk of fire or explosion.

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