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# PROTOTYPE OF LPG GAS LEAKAGE DETECTOR SYSTEM BASED ON FUZZY LOGIC

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***Abstract***

*LPG is an alternative fuel that is used for daily needs, it is caused not only because of its cheap price but also its easy* installation*. However, the characteristic of LPG gas which is flammable and heavier than oxygen makes LPG gas leakage is hard to be detected. Based on that problem, a system that is able to detect gas leakage is needed and the system itself has to pass the sensitivity level test to be gas sensor. In this study there are 3 sensors; MQ-2, MQ-5 and MQ-6 gas sensors which are connected to the Arduino Uno microcontroller as it can be used as a feature to classify the condition of the gas by the implementation of the Fuzzy Mamdani method. The output of the system is displayed on an LCD, marked with a buzzer and a fan as gas decoder. The Arduino Uno that was programmed using fuzzy logic was used to control the level of leakage and to give a solution level through the rotation of fan and the buzzer sound. From the test results, the system could determine various conditions of gas leakage with 93% accuracy. From the results of its simulation and test, MQ-5 had higher sensitivity rather than MQ-2 which had the lowest sensitivity toward gas leakage.*

***Keyword*** : *Leakage*, *LPG Gas*, *Fuzzy Logic*,

## 1. Introduction

The use of LPG as a cooking fuel is very common in the community on 2019, as it is considered to be more efficient compared to kerosene [1]. However, LPG gas also causes several problems in its use. The problems that often occur are cases of burn out or explosion caused by leakage of the gas [2]. Generally, the explosion cases of LPG gas tube are caused by gas leakage in tube, valve, and regulator. In the event of a gas leakage, there will be a stench of gas which will settle on the floor for a certain amount and it can be dangerous if inhaled as it might explode if any spark around.

Based on these problems, some studies had been conducted to prevent further losses caused by LPG gas leakage. Widyanto conducted a study to make a gas detector system using MQ6, ATMEGA328 sensors and ethernet shield which were connected to a smartphone as a monitor of LPG gas leakage[3]. Mifza Ferdian Putra completed his study by using the cayenne platform as a monitoring tool for gas leakage [4]. Lavanna Idrus made a system that is capable of detecting gas leakage and the dangerous level of gas leakage based on the level and temperature of the gas using fuzzy logic [5]. In line with those previous studies, this study made LPG gas leakage detector system based on fuzzy as a microcontroller [6]. This prototype used Arduino Uno and three gas sensors, namely MQ2 [7], MQ5 [8], MQ6 [9]. The three gas sensors have to be analyzed for their sensitivity in detecting gas leakage. An LCD is installed as the output of the detector system [10], a buzzer [11] is used as a warning and a fan [12] to spread gas out of the room.

## 2. Research Method

This system architecture is a prototype of LPG gas leakage detector system based on fuzzy logic to adjust the buzzer and fan speed as shown in Figure 1.

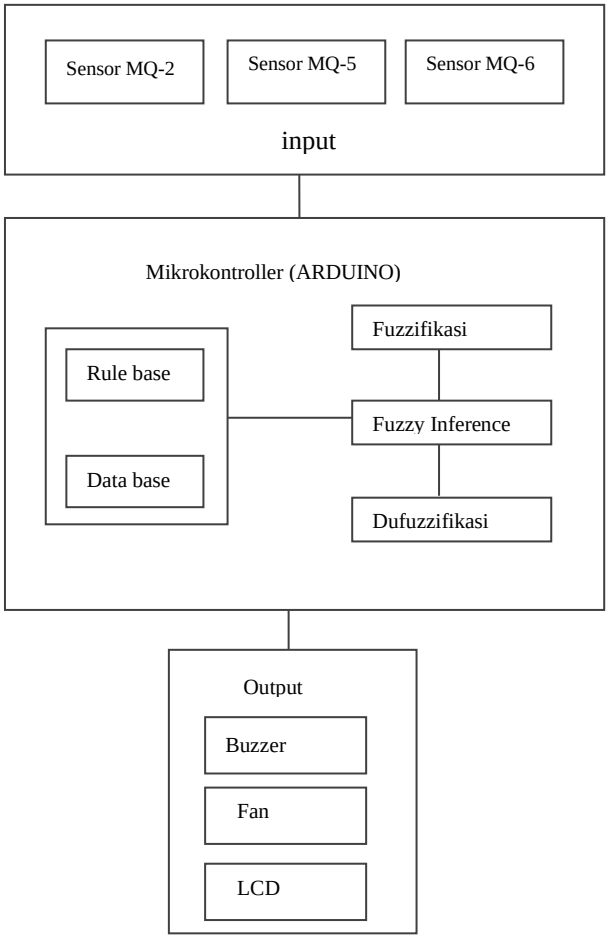


Figure 1. System Architecture

In Figure 1, the module sensors of MQ-2, MQ-5 and MQ-6 were used to detect LPG gas concentration in ppm (parts per million). These three sensors act as inputs from the system. The obtained data from the three sensors were processed in Arduino, where a fuzzy program is installed in it to determine the condition of the LPG gas leakage. The output of the system would be presented in the form of fan speed rotation and buzzer sound and displayed on the LCD. The detail of circuit prototype is provided in Figure 2.

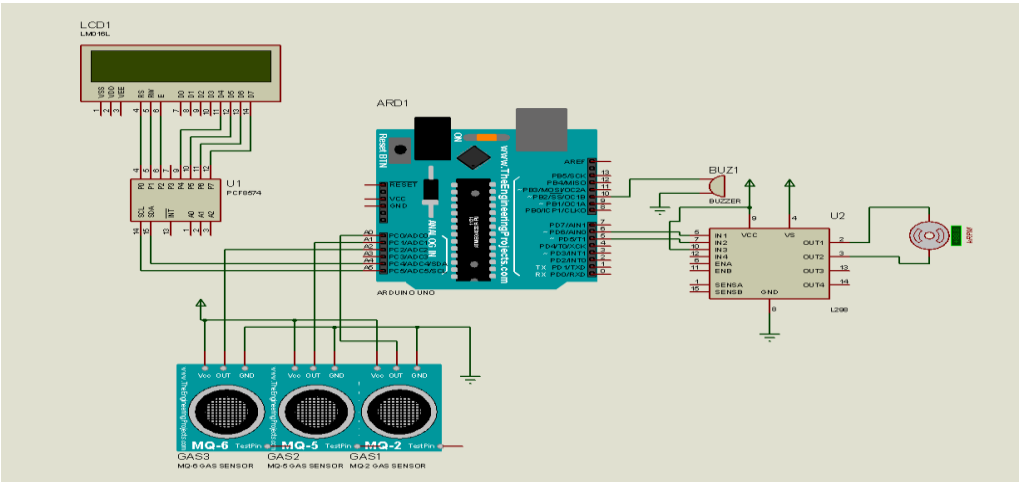


Figure 2. Set of Tools

Designing the software is started after the prototype of the hardware installation has been ready. This is because the software will control the work of the hardware. To simplify in designing the software, a flowchart must be made firstly as it described the overall process of the program in this system. There are several sub-processes in the process of designing fuzzy control such as fuzzification process, inference process and defuzzification process. Furthermore, each sub-process in fuzzy control has interrelated functions. Each sub-process would process the inputs and produce some outputs. The outputs produced by one sub-process would be used as input for the next sub-process to produce the final output. The flowchart of fuzzy control prototype could be seen in Figure 3 below.

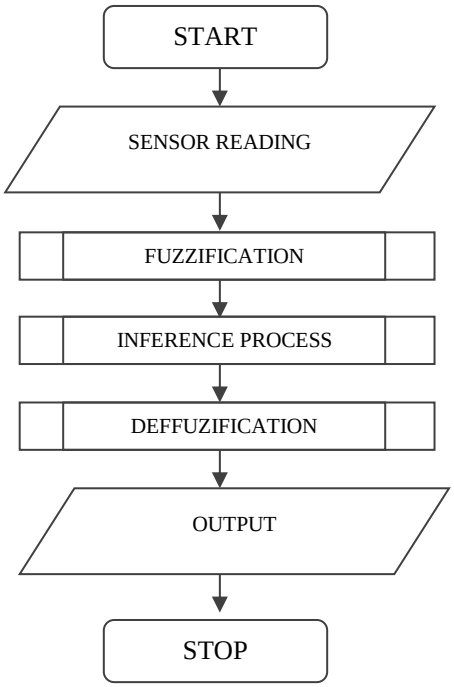


**Figure 3.** Flowchart Fuzzy Design

Flowchart or flow diagram is a sequence of instructions on creating a program. In Figure 3, it could be explained that the processing steps of Arduino fuzzy logic are as follows:

a) Sensor reading is started by initializing the component
b) Fuzzification, which is to change the input and output crisp values into fuzzy's input and output as membership functions.
c) After obtained a data from fuzzification, a basic formula is needed to find out the degree of membership of each fuzzification.
d) Design of evaluation rules to obtain the value of α predicate.
e) The Inference engine uses the MIN function for each rule so that the value alpha predicate (α) will be obtained and the composition use the MAX function to produce fuzzy new asset.
f) Defuzzification, looking for the output value which is the value of crisp (z) using the method of MOM (Mean of maximum).

## 3. Results and Analysis

The test of the three gas sensors is conducted by giving a LPG gas as a stimulant to the sensor with stimulation distances from 0 cm to 129 cm. The data obtained from the sensor detector tests on LPG gas stimulation are provided in the following table 1.

**Table 1.** Data on distance and concentration testing of MQ-2, MQ-5 and MQ-6 sensors

| No | Measurement Distance (cm) | MQ2 (ppm) | Gas concentration MQ5 (ppm) MQ6 (ppm) | Gas concentration |
|---|---|---|---|---|
| 1 | 0 | 226 | 346 | 307 |
| 2 | 3 | 208 | 333 | 297 |
| 3 | 6 | 208 | 335 | 299 |
| 4 | 9 | 193 | 316 | 284 |
| 5 | 12 | 202 | 330 | 291 |
| 6 | 15 | 187 | 297 | 274 |
| 7 | 18 | 149 | 246 | 265 |
| 8 | 21 | 107 | 143 | 259 |
| 9 | 24 | 139 | 158 | 344 |
| 10 | 27 | 124 | 147 | 197 |
| 11 | 30 | 131 | 139 | 195 |
| 12 | 33 | 114 | 133 | 156 |
| 13 | 36 | 131 | 151 | 234 |
| 14 | 39 | 112 | 130 | 189 |
| 15 | 42 | 117 | 126 | 180 |
| 16 | 45 | 80 | 106 | 125 |
| 17 | 48 | 72 | 99 | 143 |
| 18 | 51 | 99 | 104 | 125 |
| 19 | 54 | 97 | 105 | 163 |
| 20 | 57 | 102 | 107 | 131 |
| 21 | 60 | 107 | 99 | 154 |
| 22 | 63 | 113 | 100 | 145 |
| 23 | 66 | 97 | 82 | 98 |
| 24 | 69 | 102 | 82 | 105 |
| 25 | 72 | 95 | 77 | 104 |
| 26 | 75 | 74 | 69 | 95 |
| 27 | 78 | 87 | 65 | 122 |
| 28 | 81 | 70 | 53 | 105 |
| 29 | 84 | 81 | 60 | 94 |
| 30 | 87 | 64 | 52 | 65 |
| 31 | 90 | 73 | 57 | 114 |
| 32 | 93 | 85 | 63 | 111 |
| 33 | 96 | 82 | 67 | 105 |
| 34 | 99 | 66 | 58 | 79 |
| 35 | 102 | 53 | 54 | 77 |
| 36 | 105 | 73 | 61 | 115 |
| 37 | 108 | 68 | 59 | 70 |

| | | | | |
|---|---|---|---|---|
| 38 | 111 | 24 | 28 | 10 |
| 39 | 114 | 27 | 34 | 50 |
| 40 | 117 | 47 | 38 | 78 |
| 41 | 120 | 35 | 36 | 9 |
| 42 | 123 | 31 | 34 | 3 |
| 43 | 126 | 28 | 32 | -1 |
| 44 | 129 | 24 | 28 | -5 |

Based on the table above, it can be seen that the graph formed from the result of sensor reading is inversely proportional to the distance of the sensor toward the LPG gas detected. The nearest of the distance of the LPG gas stimulation to the sensor will increase the concentration detected. Conversely, the gas concentration detected by the sensor system will decrease if the LPG gas stimulation is far.

It is proven that the reading of the three sensors is more sensitive if they are brought closer to the source of stimulation. From the three sensors provided, MQ-6 has the lowest linearity value compared to MQ-2 and MQ-5. Whereas MQ-2 and MQ-5 have similar linearity results in the graph even though the ppm value is different. However, the sensitivity of MQ-5 is higher than MQ-2 and MQ6 as it's at the initial distance has a high value on reading on ppm value and its longest distance does not reach minus of ppm value as proven in Figure 4.

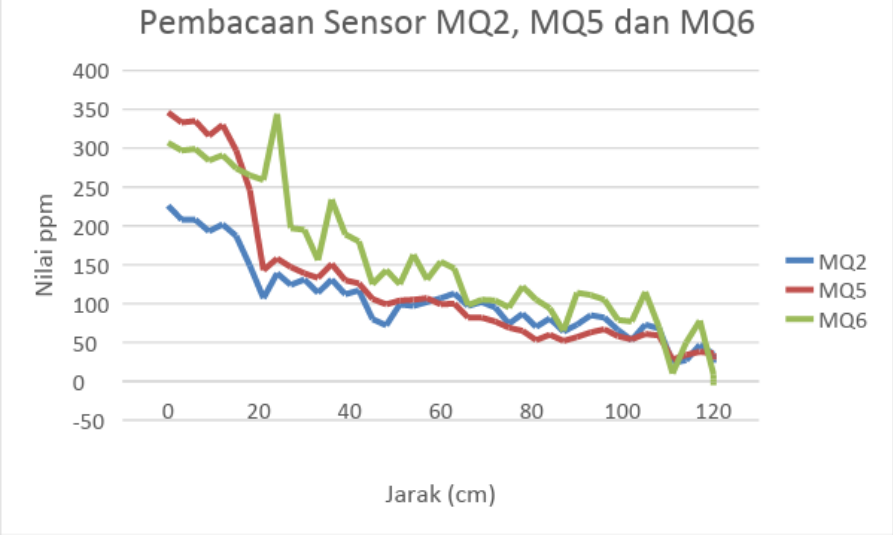


**Figure 4.** Graph of detector distance (cm) toward LPG gas concentration ( ppm) sensors MQ2, MQ5 and MQ6

Fuzzy test was conducted by measuring the value of the three sensors and also both outputs using the program of fuzzy logic and Arduino IDE before its values are compared to matlab analysis. The measurement which used Arduino obtained some results which are displayed in Table 1. The calculation of matlab analysis with fuzzy mamdani MOM can be seen in Figure 5. Comparison of values in the Arduino program and the matlab calculation are shown in Table 2.

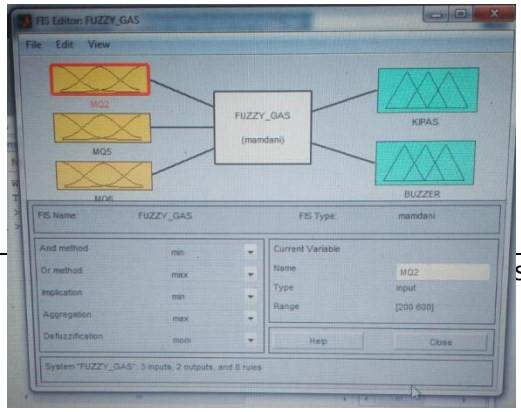


**Figure 5.** Calculation of fuzzy matlab

**Table 2.** Comparison of calculation Arduino and Matlab

| No | Distance Measure ment (cm) | **Fan rotation Arduino** | **Fan Rotation Matlab** | **Buzzer Beep Arduino** | **Beep Buzzer Matlab** |
|---|---|---|---|---|---|
| 1 | 0 | 97,5 | 97,5 | 236 | 236 |
| 2 | 3 | 95,78 | 95 | 233,25 | 233 |
| 3 | 6 | 96 | 96 | 233 | 233 |
| 4 | 9 | 93 | 93 | 229 | 229 |
| 5 | 12 | 95 | 95 | 232 | 232 |
| 6 | 15 | 90 | 90 | 224 | 224 |
| 7 | 18 | 85 | 85 | 216 | 216 |
| 8 | 21 | 84,22 | 83,8 | 214,75 | 214 |
| 9 | 24 | 97,5 | 97,5 | 236 | 236 |
| 10 | 27 | 75 | 75 | 200 | 200 |
| 11 | 30 | 75 | 75 | 200 | 200 |
| 12 | 33 | 75 | 75 | 200 | 200 |
| 13 | 36 | 80,31 | 80 | 208,5 | 208 |
| 14 | 39 | 75 | 75 | 200 | 200 |
| 15 | 42 | 75 | 75 | 200 | 200 |
| 16 | 45 | 75 | 75 | 200 | 200 |
| 17 | 48 | 75 | 75 | 200 | 200 |
| 18 | 51 | 75 | 75 | 200 | 200 |
| 19 | 54 | 75 | 75 | 200 | 200 |
| 20 | 57 | 75 | 75 | 200 | 200 |
| 21 | 60 | 75 | 75 | 200 | 200 |
| 22 | 63 | 75 | 75 | 200 | 200 |
| 23 | 66 | 75 | 75 | 200 | 200 |
| 24 | 69 | 75 | 75 | 200 | 200 |
| 25 | 72 | 75 | 75 | 200 | 200 |
| 26 | 75 | 75 | 75 | 200 | 200 |
| 27 | 78 | 75 | 75 | 200 | 200 |
| 28 | 81 | 75 | 75 | 200 | 200 |
| 29 | 84 | 75 | 75 | 200 | 200 |
| 30 | 87 | 75 | 75 | 200 | 200 |
| 31 | 90 | 75 | 75 | 200 | 200 |
| 32 | 93 | 75 | 75 | 200 | 200 |
| 33 | 96 | 75 | 75 | 200 | 200 |
| 34 | 99 | 75 | 75 | 200 | 200 |
| 35 | 102 | 75 | 75 | 200 | 200 |
| 36 | 105 | 75 | 75 | 200 | 200 |

| | | | | | |
|---|---|---|---|---|---|
| 37 | 108 | 75 | 75 | 200 | 200 |
| 38 | 111 | 75 | 75 | 200 | 200 |
| 39 | 114 | 75 | 75 | 200 | 200 |
| 40 | 117 | 75 | 75 | 200 | 200 |
| 41 | 120 | 75 | 75 | 200 | 200 |
| 42 | 123 | 75 | 75 | 200 | 200 |
| 43 | 126 | 75 | 75 | 200 | 200 |
| 44 | 129 | 75 | 75 | 200 | 200 |

Based on Table 2. The values shown on Arduino and Matlab measurements have the same values as shown in Figure 6.

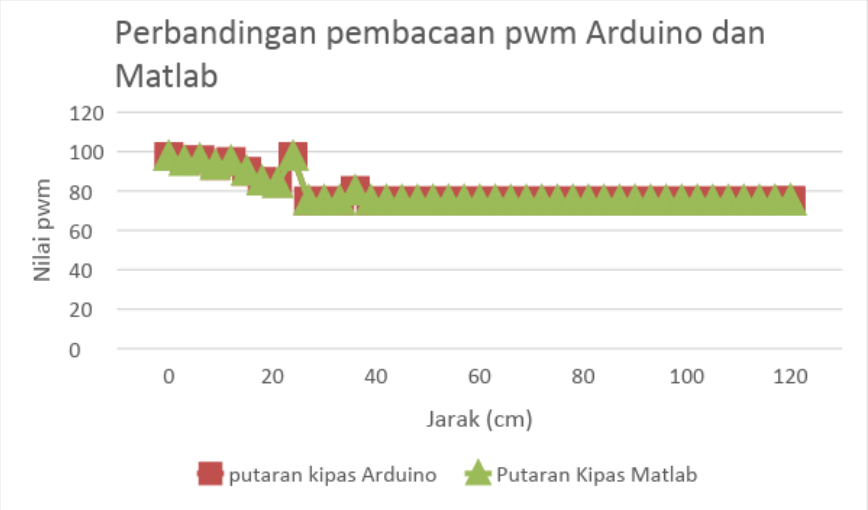


**Figure 6.** Comparison of fan rotation on Arduino and Matlab

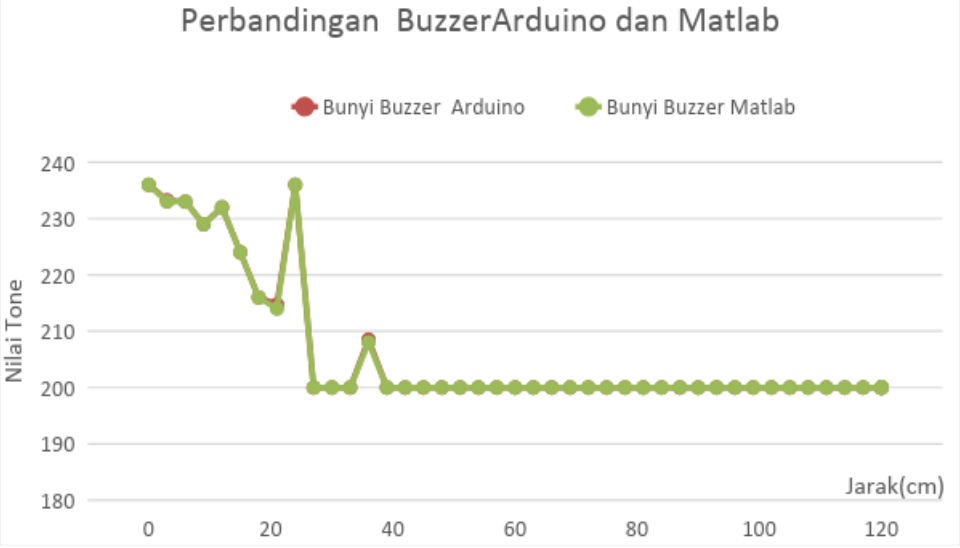


**Figure 7.** Comparison of the buzzer sounds on Arduino and Matlab

The graph shown the differences in the measurement and calculation values of three experiments, which are noted on 3 cm, 21 cm and 36 cm the distance. So the precision value for the fan pwm and buzzer sound is formulated as follows:

$$R(\%) = \left(\frac{\text{Measurement}}{\text{Calculation results}}\right) \text{x } 100\% \quad (1)$$
$$R(\%) = \left(\frac{41}{44}\right) \text{x} 100\%$$
$$R(\%) = 93.18\%$$

## 4. Conclusion

Several conclusions are obtained in this study. The prototype design of LPG gas leakage detector system with fuzzy logic had created. From the simulations and tests results, MQ-5 has the highest sensitivity rather than to MQ-2 which has the lowest sensitivity. The fuzzy system was successfully implemented to control the buzzer and fan settings with 93% precision value.

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