

Design and Implementation of LPG Leakage Detection System Using IoT-Based Regulator Lever Automation on A Household Scale

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ABSTRACT

Liquefied Petroleum (LPG) is very common in daily cooking activities. Therefore, preventive measures must be taken to reduce the risk of fire and explosion due to LPG leakages. One action that can be taken is to install a regulator lever that can open automatically when a leakage is detected. In this research, Pulse Width Modulation (PWM) is used to control the rotational speed of the servo motor on the regulator lever, which aims to implement an automatic control system that is responsive when an LPG leakage is detected. Using servo motor control to automatically open the regulator lever can reduce the impact of accidents or losses due to LPG leakages. The test results show that the regulator lever can be opened effectively with a pulse value of 0.55 ms at a rotation angle of 0° in 0 seconds, while it can be closed with a pulse value of 2.45 ms at an angle rotation of 180° in 1.66 seconds. This shows that the regulator responds appropriately to the level of danger detected and is precise in adjusting position. The use of PWM on servo motors in the regulator control system has proven effective in increasing responsiveness to LPG leakages, as seen from the fast response (0 to 1.66 seconds) and accuracy (100% success percentage for 15 trials). This shows that using PWM can respond to emergencies quickly and precisely.



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1. INTRODUCTION

With the continued development of technology, information and industry, Indonesia's energy needs are increasingly becoming important in people's daily lives. The role of natural resources, especially fossil energy such as petroleum, in people's livelihoods shows that availability is increasingly limited [1]. Therefore, reducing dependence on fossil energy is necessary by switching to more sustainable natural resources such as natural gas [2]. Since 2007, the Indonesian government has implemented a kerosene to Liquefied Petroleum Gas (LPG) conversion program to convert subsidised kerosene users, especially those from economically disadvantaged groups, into LPG users as part of energy transformation efforts [3].

LPG is a hydrocarbon gas produced from oil refineries and gas refineries [4]. The main components are Propane and Butane gas, packaged in tubes [5]. LPG has a variety of applications, with its primary use as a cooking fuel [6]. Apart from that, LPG is also used as fuel in the food, glass, and ceramics

industries and as fuel for forklifts [7]. LPG is flammable and can explode when a leakage occurs and is exposed to a fire source [8]. In the initial phase of converting to LPG, new users must adapt to cooking devices such as stoves, hoses and regulators [9]. Data from the National Consumer Protection Agency recorded incidents of LPG explosion accidents in 2007, 2008 and 2009 as 5, 27 and 30. Until 2017, reports of LPG-related accidents still occur frequently, highlighting the urgency of attention to the safety of LPG use [10].

To reduce the risk of accidents that LPG leakages can cause, the increasing use of LPG as an energy source in households creates a need to improve security and leakage detection systems [11]. The safety aspect of LPG is essential, considering the potential risks that could arise from gas leakages [12]. Therefore, the existence of an LPG Detector (Tor-G) is a very relevant and essential step in efforts to design and implement an LPG leakage detection system with the Internet of Things (IoT)-based regulator lever automation on a household scale [13].

2. RESEARCH METHOD

This research was conducted to evaluate the performance of servo motors in opening and closing the regulator lever with a focus on operational reliability. Meanwhile, assessing the speed of servo motor response to LPG leakage detection is designed to measure the system's effectiveness in responding to emergencies [14]. This research focuses on the Regulator Automation subsystem. The methodological flow diagram of this research can be seen in Figure 1.

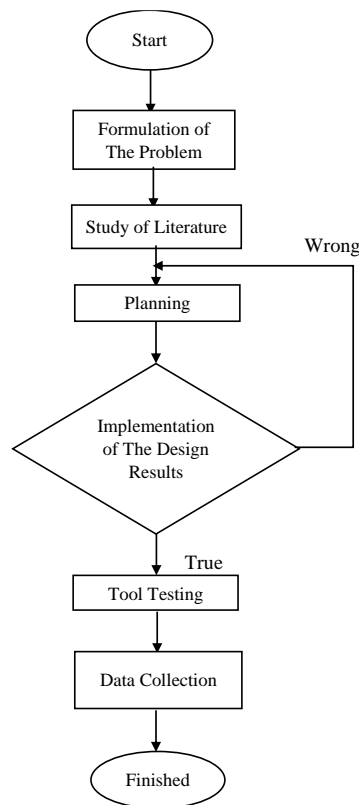


Figure 1. Flowchart of research methodology

This research began by formulating problems related to the regulator automation subsystem. After developing the problem, the author conducted a literature study to gain an in-depth understanding of the problem to be solved. Determining the literature study involves several stages until finalisation, including specification of tool requirements, design, implementation and testing.

The determination of tool specifications is based on the results of literature studies and is the focus of the Final Project research on the regulator automation subsystem. After obtaining the specifications for tool requirements, the author carried out a design, which was then implemented and tested. If the

test is inappropriate, the author returns to the design stage. On the other hand, if the tools are suitable, the author continues his research.

2.1. Regulator Automation Testing Methods

Next are the steps taken in regulator automation testing:

1. Make sure the NodeMCU ESP8266 is connected to the internet according to the initialisation in the source code and verify the success of sending gas sensor data. Ensure the gas sensor data is successfully detected and the servo motor automatically opens and closes the regulator lever according to the desired command.
2. Prepare a program on the Arduino IDE to set the servo motor angle and a protractor to compare the set angle with the measured angle.
3. Make sure the program on the NodeMCU ESP8266 can send PWM signals with a duty cycle and carry out tests by varying the duty cycle.

3. RESULTS AND DISCUSSION

The following are the results of tests carried out for regulator automation. Table 1 shows the regulator's response to LPG levels detected by the MQ-2 sensor. This table includes various gas concentrations in units (ppm), conditions and regulator responses, with each condition being taken 5 times [15].

Table 1. Regulatory response

Gas concentration (ppm)	Condition	Regulator response
6,61	Safe	Closed
12,94	Safe	Closed
74,71	Safe	Closed
88,89	Safe	Closed
93,97	Safe	Closed
678,70	Standby	Closed
688,10	Standby	Closed
697,60	Standby	Closed
748,00	Standby	Closed
758,70	Standby	Closed
1019,00	Danger	Open
1119,00	Danger	Open
1155,00	Danger	Open
1232,00	Danger	Open
2314,00	Danger	Open

Angular responsiveness testing is carried out to assess the servo motor's ability to rotate according to the desired angle. This test involves comparing the angle set on the servo motor and the angle measured using a protractor. This test was performed 9 times at various angles, as in Table 2.

Table 2. Angular responsiveness results

Set the Angle on the servo motor (°)	The angle on a protractor (°)
0	0
30	30
45	45
60	60
90	90
120	120
135	135

Set the Angle on the servo motor (°)	The angle on a protractor (°)
150	150
180	180

The data results above showed that each experimental angle matched the angle set on the servo motor and the angle measured using a protractor. This data will then be processed using Microsoft Excel to produce a graph showing the relationship between the servo motor angle and the protractor angle, as shown in Figure 2.

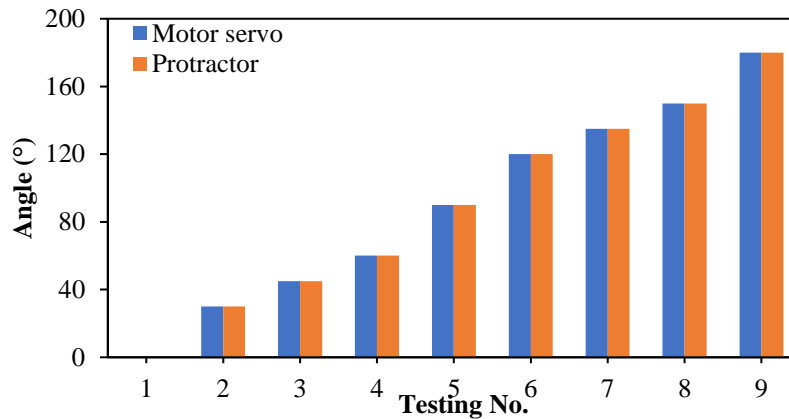
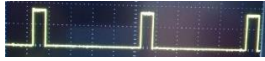



Figure 2. Servo angle responsiveness graph

This test is carried out by varying the pulse value from 0.55 milliseconds to 2.45 milliseconds to determine the shape of the pulse and the speed at which the servo motor moves according to the desired angle.

Table 3. Time responsiveness results

Pulse (ms)	Pulse Form (%)	The angle on the servo motor (°)	Time (s)
0,55		0	0,00
0,80		30	1,23
1,05		45	1,26
1,25		60	1,27
1,50		90	1,32
1,75		120	1,36
1,95		135	1,39

Pulse (ms)	Pulse Form (%)	The angle on the servo motor (°)	Time (s)
2,20		150	1,49
2,45		180	1,66

Based on the data obtained, it is known that each pulse value produces a different pulse shape and time. This data is then processed using Microsoft Excel to create a graph showing the relationship between the pulse and the angle of the servo motor and the time required as shown in Figure 3.

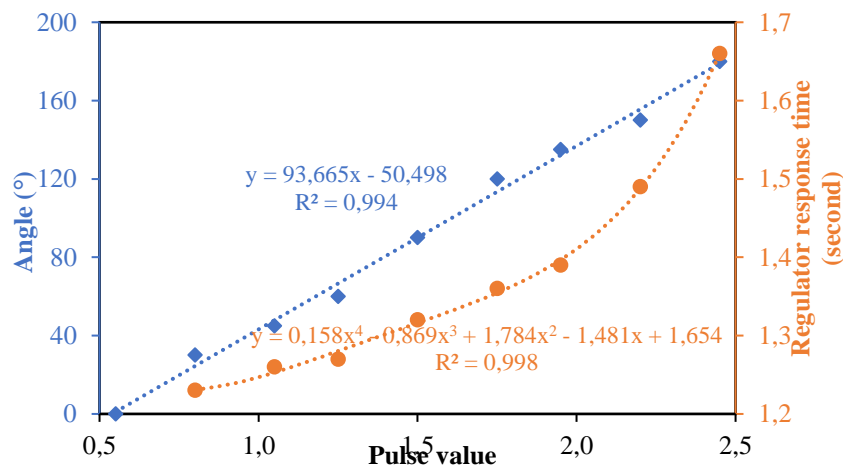


Figure 3. Time responsiveness graph

4. CONCLUSION

The servo motor shows excellent and optimal performance in opening and closing the regulator lever. In 5 experiments carried out in each condition, the results showed that when in a safe and alert condition, the regulator lever remained closed. However, when in a dangerous condition, the regulator lever will open. The servo motor has proven to be effective in responding to LPG leakage detection which is read on the MQ-2 sensor. With high speed and consistency in emergency situations, servo motors demonstrate reliable adaptability and effective response in the face of dangerous conditions. To open the regulator lever automatically, the effective angle is 0° with a pulse value of 0.55 ms and the response time is 0 seconds. Meanwhile, to close the regulator lever, the effective angle is 180° with a pulse value of 2.45 ms with a response time of 1.66 seconds.

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