Protection and Monitoring System for LPG Leaks and Fires in Arduino-Based Rooms

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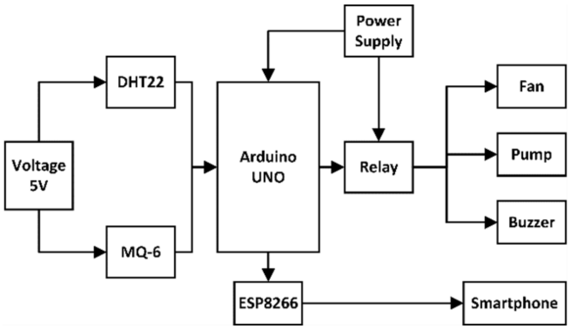
ABSTRACT



This research is a development of previous research in overcoming of LPG gas leaks that cause fires. The system is designed using the main sensor MQ-6 and DHT22 sensors which will detect the gas concentration and temperature in the room, the protection system is equipped with an exhaust as a room freshener and a buzzer as a direct warning alarm and a water pump to extinguish a fire. And all of data will be displayed on the application Blynk and will send a notification on email users by using a Wi-Fi network. This system has succeeded in detecting the concentration of LPG gas with a sensor detection distance of 1 cm to 7 cm getting an average time of 1.6 seconds and percentage of error comparison 2.52%. In normal temperature detection, the percentage error is 1.14% and normal humidity is 2.98%, As for detection of rising temperature by using of wax media, the percentage error is 1.84% and humidity 1.87%. From these tests and getting results with a small percentage value this system can already be used and runs as well.

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1. INTRODUCTION

The rapid development of technology can play a role in overcoming problems that occur among the community, one of which is in reducing the number of fires, according to BNPB (National Disaster Management Agency) there have been 500 cases of forest and settlement disasters throughout 2018, one of which is LPG gas leakage [1]. In the case of fires that occur due to LPG gas caused by oxidation that occurs due to three elements, namely fuel, oxygen and heat sources The fire will not ignite if the three elements are not met [2].

In fire detection using various innovations carried out in research by adjusting factors and conditions in the field and adjusting the devices used to obtain the desired research results. The selection of detection devices greatly affects the performance of the system, the use of F lame detector sensors is very effective to find out if a fire occurs but in placement in a room such as a kitchen sensor can at any time occur errors in detection as well as the use of smoke detectors [3][4][5][6][7]. As well as supporting the monitoring system in the room, it is needed in the use of IoT (Internet of Things) technology which can provide information in real-time and is easier to use compared to its predecessor technology such as the use of SMS Gateways etc. [8].

Based on these problems, a system is designed that can detect LPG gas leaks and can overcome fires by adjusting the device used, using an Arduino Uno microcontroller and an MQ-6 sensor in LPG gas detection and a DHT22 sensor to determine the temperature and humidity in the room. Equipped with a room freshener system using an Exhaust fan as well as a warning alarm using a buzzer and a water watering system consisting of a water pump connected to a nozzle using a hose. To monitor this system is supported by the ESP8266 Wi-Fi module which can connect the device with the internet then send information data and will be displayed on the Blynk application and send a notification to the user's email.

2. METHODS

This study focuses on the performance of the main device in the form of sensors by comparing the value of the detection results which will get the final value in the form of error percentage and testing on protection systems, hardware and software that functions to find out if the device used can work according to the circumstances in the detection room.

2.1. System Design

In the design of this protection and monitoring system, a block diagram was made to be able to help in designing the entire system that can be seen in Figure 1.

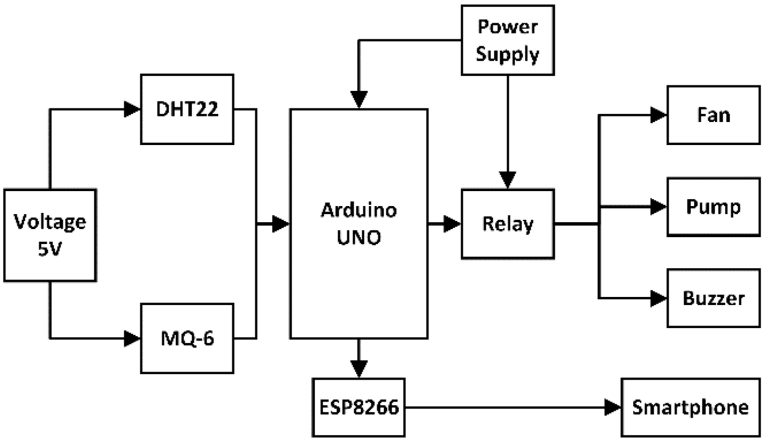

Figure 1. System block diagram

Based on Figure 1 It can be found that in this system there are three main parts, namely input, process and output. In the input section itself, there is an MQ-6 sensor which is used to detect gas concentrations and the DHT22 sensor is used to detect temperature and humidity then from the results of the data obtained from the sensor will then be sent to a microcontroller in the process section in the form of analog data and will be converted into digital data using the ADC feature. The digital data will be variable to control the output part of the system and will display information on a smartphone and then sent over the internet network using the ESP8266 module [9][10][11][12][13]. The use of the ESP8266 module which is integrated with the TCP/IP protocol which provides access to the microcontroller to access Wi-Fi, is very helpful in the process of sending data to the internet network [14][15]. After made a system design using a block diagram that further connects the Arduino Uno device with other devices. Here is the series of the entire system in Figure 2 [16].

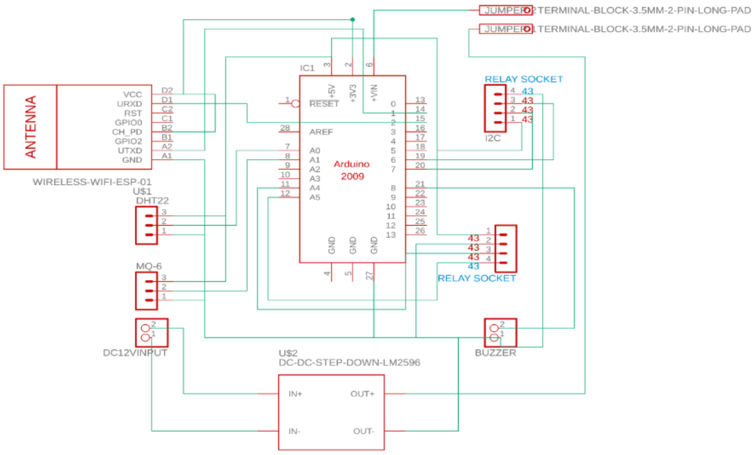

Figure 2. System schematic circuit

2.2. Equations

2.2.1. LPG Gas Concentration

In the reading of the LPG gas concentration value through the MQ-6 sensor in the form of an analog value, the RS / RO value will be searched using calculations that can be seen in Equation (1).

$$RS = \left(\frac{VC - VRL}{VRL}\right) \times RL \tag{1}$$

With:

RS is the sensor resistance, VC is maximum voltage on the sensor, VRL is minimal voltage on the sensor, and RL is resistance in the sensor circuit.

Then to find the PPM value of LPG gas, a natural log will be used which can be solved using Equation (2).

$$\text{PPM} = \left[\frac{\frac{RS}{RO}}{18{,}442}\right]^{\frac{1}{-0{,}421}} \tag{2}$$

With:

PPM is the concentration of gases in the air, RS is of sensor resistance, and RO is the clean air content.

The use of the MQ-6 sensor that detects the value of LPG gas concentration in the form of analog values, so that to convert these values, manual calculations will be used which will then be entered into the program uploaded to the Arduino [17].

2.2.2. Average

To find the average, the calculation of errors or differences with the comparison of measuring instruments used using Equation (3) and Equation (4) is first carried out. Then to find the average, namely by summing up all the data (errors) divided by the total number of samples.

$$e = |x - y| \tag{3}$$

$$x = \frac{\sum_i^n = 0}{n} = \frac{e1 + e2 + e3 + \cdots \ldots \ldots}{n} \tag{4}$$

Information:

e is error/sensor measurement difference, y is measurement results of measuring instruments, x is of sensor measurement results, en is the number of measurement results, and n is the number of average sample measurements or errors.

2.3. Algorithms

In the program uploaded to the Arduino microcontroller which will receive data from the main sensor on the system will then be sent using a Wi-Fi network through the ESP8266 module. The following can be seen a program of temperature and humidity readings and gas concentrations on Listing 1.

```
Temp = dht.readTemperature();
Hum = dht.readHumidity();
       }
void GasSensor()
       {
float sensorValue = analogRead(A1);
sensor_volt = sensorValue*5.0/1024;
RS_gas = ((5.0*RL)/sensor_volt)- RL;
ratio = RS_gas/R0;
x = ratio/18.442;
Gas_Kal = pow(x,-2.375);
       }
```

Listing 1. Temperature and humidity reading program as well as LPG gas

In the program in Listing 1 there is a temperature variable which is used to read analog values which will then be converted to which can be used as a temperature meter, and the Hum variable is also used to change the analog sensor value which can be used as a humidity meter in the room. In the next variable where the program code initializes pin A1 on the Arduino which functions to read the analog value of the sensor will then be changed using Equation (1) and Equation (2) to convert the value read from the MQ-6 sensor to a value that can be used as a reference for testing [18].

After designing the program code, it is hoped that the program uploaded on the Arduino can run as desired as in the flow program which can be seen in the Figure 3.

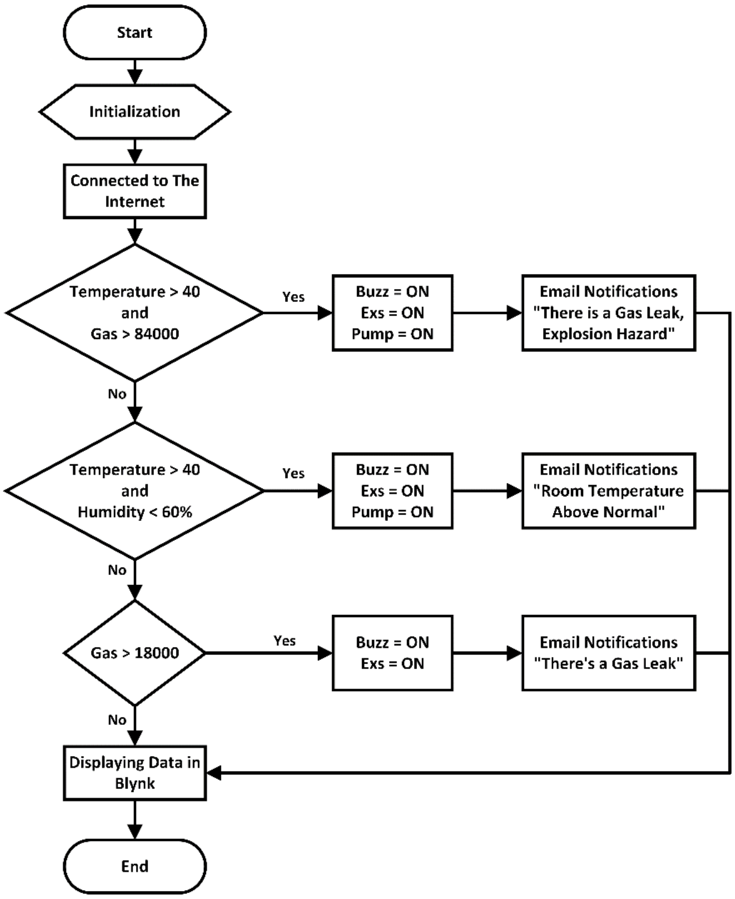

Figure 3. System flow chart

At first the device is turned on and starts initializing and connecting to the internet network then it will start detecting past the condition conditions which if not met then the system will send information data and display it to the Blynk application, the temperature and humidity values in the condition of the requirements are values based on the highest value obtained in the room, then at the limit of LPG gas values based on the Lower Explosive Limit (LEL) [19][20].

3. RESULTS AND DISCUSSION

After designing, the results are obtained in the form of a protection and monitoring system tool on gas leaks that are ready to be used, this hard circuit is used to assist in early detection if at any time there is a gas leak where this tool will send a signal to users with the help of an internet connection that will send notifications with the help of software Blynk can directly facilitate users in the operation of this tool so as to reduce worries if at any time there is a gas leak in LPG. This test is carried out including the detection of conditions in the room that produce data in the form of temperature and humidity as well as values on LPG gas concentrations, the data will be compared with comparison variables, then testing on the protection system and monitoring on the device to find out if the system is working as desired.

3.1. MQ-6 Sensor Testing

In this test, it is to detect gas using a lighter that will be sprayed on the MQ-6 sensor with the intention of knowing the PPM value issued by the sensor, here is data from the sensor detection results that will be compared with the sensor datasheet itself which aims to find out how big the error percentage rate of the device can be seen in Table 1.

Table 1. The results of MQ-6 sensor testing

No.	Rs/Ro	Data of MQ-6 Gas Sensor		Error (%)
		Datasheet (PPM)	Sensor (PPM)	
1	2	200	195.59	2.2
2	1.8	300	251.20	16.3
3	1.6	400	332.28	16.9
4	1.5	500	387.32	22.5
5	1.4	600	456.28	24.0
6	1.3	700	544.09	22.3
7	1.2	800	658.01	17.7
8	1.1	900	809.07	10.1
9	1	1000	101.59	1.5
10	0.75	2000	2009.20	0.5
11	0.65	3000	2822.44	5.9
12	0.56	4000	4021.12	0.5
13	0.50	5000	5263.08	5.3
14	0.48	6000	5798.90	3.4
15	0.45	7000	6757.59	3.5
16	0.43	8000	7530.19	5.9
17	0.40	9000	8941.31	0.7
18	0.38	10000	10099.68	1.0

From Table 1. di know the results of the comparison of data from the MQ-6 sensor with its comparison variable, namely the sensor datasheet itself, while the data released by the sensor itself is the result of the conversion of sensor analog values using Equation (1) and Equation (2). Here is the comparison chart data in Figure 4.

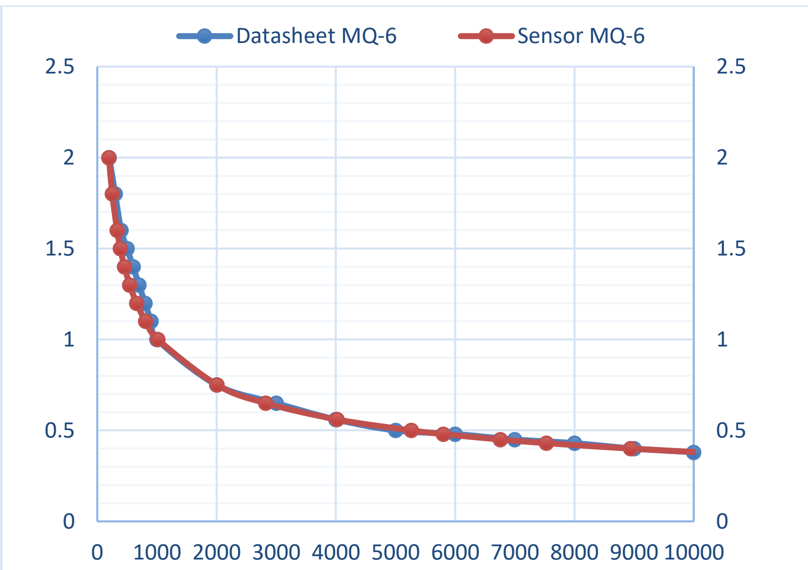

Figure 4. Comparison chart of MQ-6 sensors

3.2. DHT22 Sensor Testing

3.2.1. Measurement and Comparison During Normal Conditions

Testing the DHT22 sensor during normal conditions in the room to find out how much the sensor value level will be compared with the HTC2 measuring instrument in detecting temperature and humidity at the time of reading under normal conditions. The following data was obtained in Table 2.

From the results of Table 1 Then you can search for the average value of each test and then you will find the error percentage value using Equation (2). Next will look for the average value of the temperature value in the DHT22 sensor which can be seen in the following calculation.

$$rata-rata = \frac{28.2 + 28.6 + 28.4 + \cdots + 27.7}{30} = 28.29$$

From the results of this calculation, the average result on normal temperature detection in the DHT22 sensor was ±28.29. With the same calculation, you can find the average value of other tests, namely the humidity test on the DHT22 sensor gets an average of ±82.83 while the average in the comparison variable, namely HTC2, gets the average value on the normal temperature measurement of ±28.62 and humidity of ±80.43. Then to get the error percentage value, Equation (2) will be used. The following is a calculation of the percentage of errors at normal temperatures from both measurements which can be seen as follows.

$$error(\%) = \left|\frac{28.29 - 28.62}{28.62} \times 100\right| = 1.14\%$$

From the calculation, the error percentage value from the normal temperature measurement is ±1.14%. By using the calculation that is the same as before, the result of the percentage of error from the normal humidity measurement of ±2.98% is obtained. Here's a comparison chart of the test results which can be seen in Figure 5 and Figure 6.

Table 2. The results DHT22 sensor testing in normal condition

Time	DHT22		HTC2	
	Temperature (°C)	Humidity (%)	Temperature (°C)	Humidity (%)
01.27.01	28.20	82.60	28.7	81
01.28.18	28.60	82.60	28.7	81
01.29.05	28.40	82.40	28.7	80
01.30.56	28.50	82.90	28.9	80
01.34.31	28.40	82.90	28.6	80
01.34.47	28.40	82.70	28.6	80
01.34.58	28.40	83.10	28.6	80
01.35.18	28.00	82.40	28.6	80
01.35.50	28.40	82.90	28.6	80
01.36.27	28.00	82.70	28.6	80
01.37.05	28.50	83.20	28.6	80
01.37.36	28.40	83.20	28.6	80
01.38.28	28.60	83.50	28.6	80
01.39.13	28.30	82.90	28.6	81
01.40.38	28.70	83.50	28.6	81
01.40.56	28.30	83.00	28.6	81
01.41.16	27.80	82.60	28.6	81
01.41.47	28.60	83.00	28.6	81
01.42.27	28.40	82.70	28.6	81
01.43.02	27.90	82.50	28.6	80
01.43.46	27.70	82.20	28.6	81
01.44.59	27.80	82.50	28.6	81
01.45.20	27.90	82.70	28.6	81
01.46.04	28.50	83.40	28.6	81
01.47.17	28.60	83.10	28.6	80
01.47.45	28.60	82.70	28.6	80
01.48.00	28.40	83.10	28.6	81
01.48.24	28.30	82.90	28.6	80
01.49.21	28.50	82.80	28.6	80
01.50.05	27.70	82.30	28.6	80

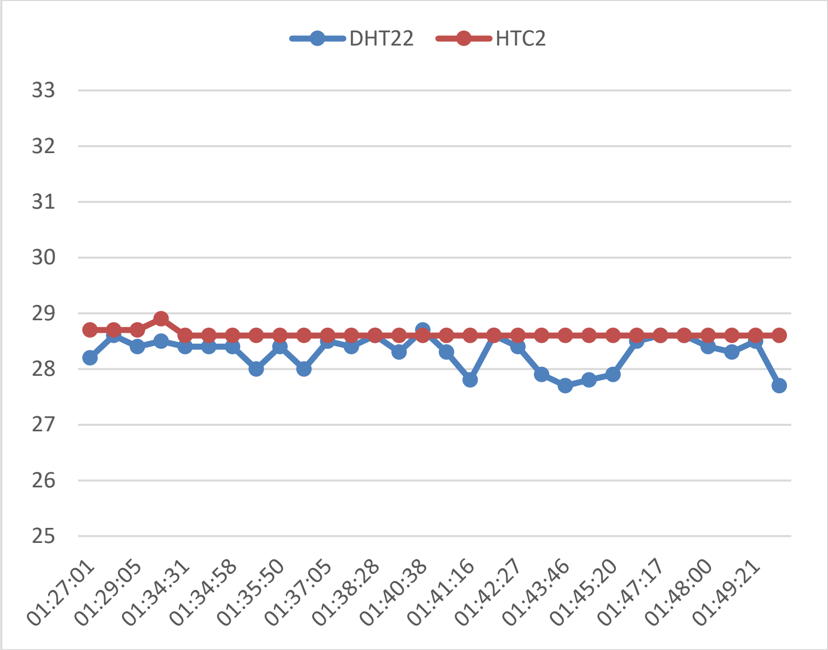

Figure 5. Normal temperature comparison chart

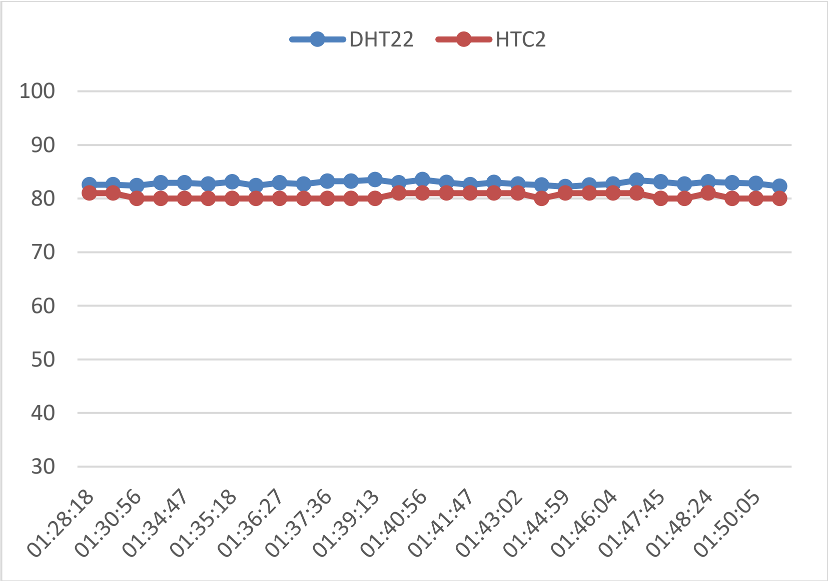

Figure 6. Normal humidity comparison chart

3.2.2. Measurement and Comparison with The Help of Candles

With the help of a candle media that if ignited can help in raising the temperature and lowering the humidity in the room, therefore this comparison is intended to help detect the sensor in detecting temperature changes and lowering the humidity in the room and making comparisons using the HTC22 measuring instrument. It can be known from Table 3 is data from the results of sizing with the help of using candles to increase the temperature around the detection room to find out the average and percentage of error from the measurement, Equation (2) will be used. With the same calculations as before. Then the average result of room temperature on the DHT22 sensor was ±38.16 and humidity of ±61.97. Meanwhile, the comparison variable, namely HTC-2, received an average temperature measurement of ±37.69 and humidity of ±60.83.

After knowing the average value of each measurement, a calculation can be made to get the percentage of error with Equation 2. with the same calculation as before, the results of calculating the percentage of error from the two measurements of the DHT22 and HTC-2 sensors were obtained at a room temperature ratio using candles of ±1.24 and humidity of ±1.87%. Here is a comparison chart of measurements using candles which can be seen in Figure 7 and Figure 8.

Table 3. Measurement data using the help of candles

Time	DHT22		HTC2	
	Temperature (°C)	Humidity (%)	Temperature (°C)	Humidity (%)
02.34.09	29.20	78.30	29.6	78
02.34.54	29.40	81.50	29.6	79
02.35.12	30.20	82.30	30.1	79
02.35.45	30.40	78.80	30.3	78
02.36.01	30.20	79.70	30.3	77
02.36.53	32.40	77.60	30.3	76
02.37.10	33.60	75.70	32.3	72
02.37.30	34.80	73.50	33.3	72
02.38.06	36.40	69.70	35.4	67
02.38.55	37.10	66.40	36.8	65
02.39.58	38.90	61.60	38.1	60
02.40.26	40.10	60.10	39.5	60
02.40.55	41.00	57.70	39.8	57
02.41.19	41.40	55.90	39.7	55
02.41.52	41.70	54.10	40.6	52
02.42.36	42.60	51.50	41.5	51
02.43.01	42.90	50.40	42.3	49
02.43.35	43.20	50.40	42.2	50
02.44.09	43.40	48.90	43	49
02.45.04	43.40	48.30	43.2	49
02.46.00	43.70	45.60	44.8	48
02.46.50	43.40	46.70	44.2	47
02.47.11	43.30	46.40	44.2	45
02.47.55	43.10	46.20	43.5	45
02.42.36	42.60	78.30	41.5	78
02.43.01	42.90	81.50	42.3	79
02.43.35	43.20	82.30	42.2	79
02.44.09	43.40	78.80	43	78
02.45.04	43.40	79.70	43.2	77
02.46.00	43.70	77.60	44.8	76

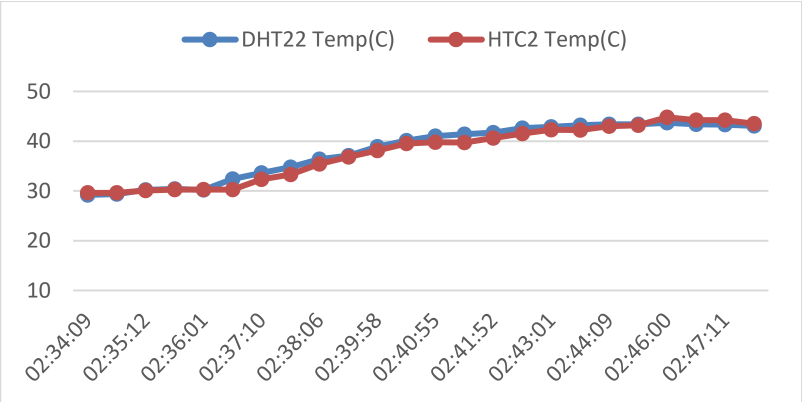

Figure 7. Temperature comparison chart using candles

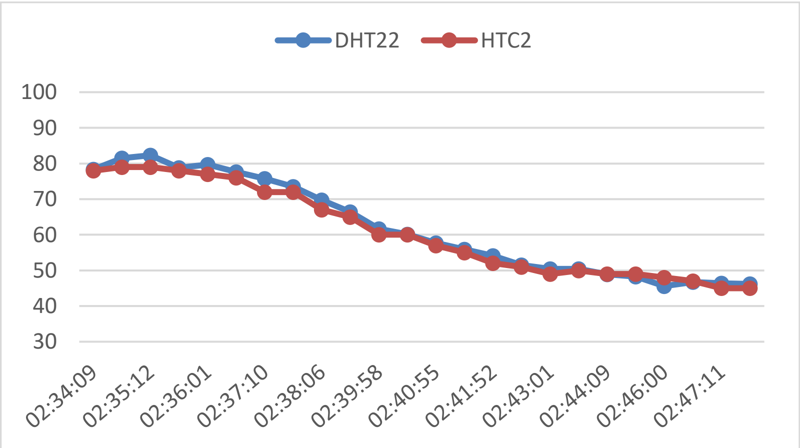

Figure 8. Moisture comparison chart using wax

4. CONCLUSIONS

Based on the results of the tests carried out, it has succeeded in creating an LPG gas and fire protection and monitoring system supported by a network based on IoT (Internet of Things) that can always be monitored at any time displayed on the Blynk application. Then this study also succeeded in testing sensors on system devices using a comparison method and had a varying percentage of errors. Among them, in the comparison of MQ-6 sensors, they get an error percentage value of ±2.52%, for a DHT22 sensor in normal temperature measurements it gets a value of ±1.14% and humidity ±2.98%, while in measurements on the DHT22 sensor using candles get a percentage error value on temperature measurements of ±1.84% and humidity of ±1.87%.

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