Design of automatic fire extinguishing system with interactive web display

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Abstract— An automatic fire extinguishing system prototype has been designed. This design consists of software and hardware design. Software design involves sensors, actuators, controllers, sim900 modules and website interfaces. Hardware design is to make a prototype fire extinguishing system. Fire extinguishing system testing is done by testing the system's components such as sensors, actuators, sim900 modules, and website responses to the database. LM35 Sensor testing resulted in a measurement error of 3.29% with a measurement accuracy of 96.8% and MQ135 Sensor testing resulted in an error of 16.6% with a measurement accuracy of 90.4%. The MQ135 Sensor error is quite large because the standard measuring instrument used as a comparison measures changes in ppm levels very quickly. The actuator test results show that the buzzer can provide notification when the LM35 Sensor exceeds the set point of 57 °C and the MQ135 Sensor reaches 101 ppm. The relay is active when both sensors have reached the set point, and the pump will turn on to extinguish the fire. The results of testing the entire system show that the sensor works well in detecting temperature and smoke level changes so that the actuator will turn on when the temperature and smoke levels have reached the set point. The SIM900 module will send an SMS to the user if a fire is indicated. The interface of this system displays the temperature measurement levels and smoke levels in real time on the website.

Keywords— Design, Automation System, Fire Fighting.

1. INTRODUCTION

Fire is an event that causes great losses. The fire extinguishing system used in the instrumentation engineering department is still manual in operation. This system is still ineffective because it cannot handle fires in real time. A manual extinguishing system can cause large losses if the fire is not extinguished immediately.

Various innovations in fire extinguisher prototype technology have been developed to extinguish fires automatically when a fire occurs as done by designing an automatic fire extinguisher with room temperature and humidity control using fuzzy logic. In this design, it can detect fires relatively quickly and can receive and transmit data without data loss, but the sensors used have less sensitivity and less fast response time. In addition, research conducted from [1-6] on designing an IOT-based fire detection system and SMS Gateway using android has a fairly fast speed for sending information to related parties, which is around ≤5 minutes. The disadvantage of this design is that the fire sensor is not enough to reach a large area, so a wide range sensor is needed to be applied in the forest.

Based on these problems, for early prevention of fire in the instrumentation engineering department building, it is necessary to design an automatic fire extinguishing system. This system can be used to monitor the potential for fires such as smoke levels and high temperatures. smoke levels will be monitored using the MQ-135 sensor and temperature using the LM35 sensor. So that when smoke and temperature levels are detected that exceed normal limits, the relay will be active and the spray nozzle will spray water to extinguish the fire. The controller used in this system is ESP32 which can also be used to send data to the database. Measurement data will be recorded in mySql. This system will provide notification in the form of SMS so that it can be known if there is a fire in the instrumentation engineering department. This fire extinguisher automation system is expected to prevent fires and reduce the risk of losses caused by fires in the ITS Instrumentation Engineering department.

2. METHOD

2.1. The research procedure

The following procedure of this final project is as follows:

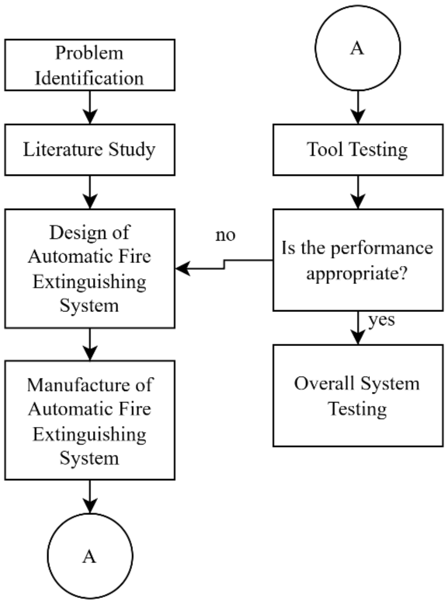

Figure 1 Research Flowchart

2.2. Prototype Design

The following is the design of the automatic fire extinguishing system prototype:

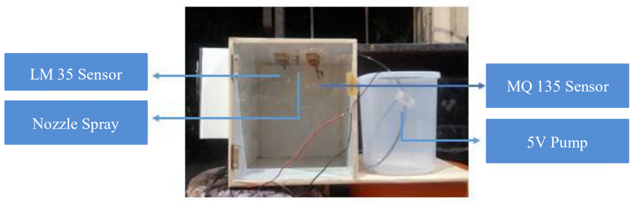

Figure 2 Prototype Design of Automatic Fire Extinguishing System

Figure 3 Panel Box

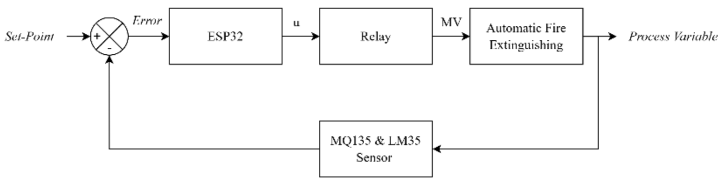

Figure 4 Block Diagram

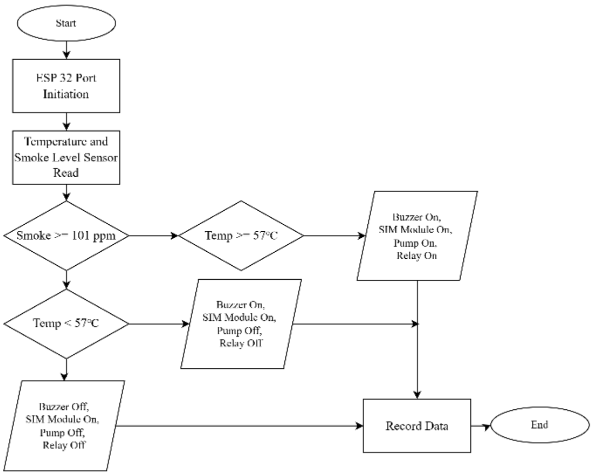

Figure 5 Flowchart of Automatic Fire Extinguishing System

The design scheme of the fire extinguishing system is as follows:

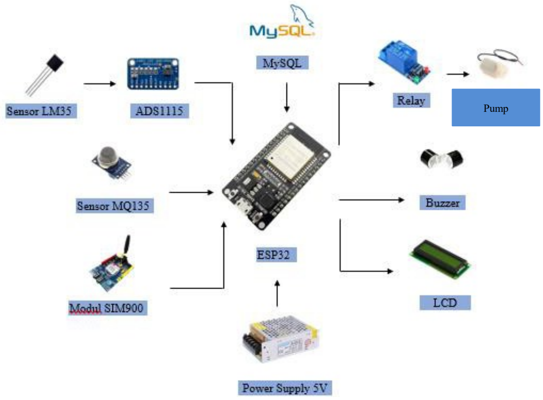

Figure 6 System Design Schematic

2.3. ESP32 Specifications

Figure 7 ESP32

The specifications of the ESP32 Dev Kit are as follows:

Table 1 ESP32 Specification

Total Pin	30pin (15x2)
Board Size	52 x 28.5 mm
USB Driver	CP2102
Wifi Protocol	802.11 b/g/n (802.11nup to 150 Mbps)
Frequency	2.4 GHz~2.5 GHz
Bluetooth	v4.2 BR/EDR and BLE with –97 dBm sensitivity
SPI Flash	4MBit
Internal Clock	40Mhz
Chip Op Voltage	2.7~3.6V DC
Module Op Voltage	5V DC via MicroUSBport
Op Current	80mA
Minimum USB Current	500mA

Interface	SD card, UART, SPI, SDIO, I2C, LED PWM, Motor PWM, I2S,IR, pulse counter, GPIO, capacitive touch sensor, ADC, DAC
On-chip Sensor	Hall Sensor
Audio	CVSD and SBC
Supporting three modes	AP, STA, and AP+STA
Support Arduino IDE	
Strong function with support LWIP protocol, Freerto	
Supporting Lua program, easily to develop	

The ESP32 port used in this research are as follows:

Table 2 Port ESP32 DEV KIT

PIN	Function
GPIO36 (ADC1 CH0)	Input sensor MQ135
D4	Buzzer
D23	Relay
GPIO 22	SCL LCD I2C &ADS1115
GPIO 21	SDA LCD I2C &ADS1115
Port Rx	RX Modul SIM
Port TX	TX Modul SIM

2.4. LM35 Sensor Specifications

Figure 8 LM35 Sensor

The specifications of the LM35 sensor are as follows:

Table 3 LM35 Specification

Calibration Unit	℃
Working Voltage	4 – 30 Vdc
Temperature Range	-55 – 150 ℃
Linierity	+10 Mv/℃
Accuracy	0.5℃
Output Voltage	-1 Vdc s/d +6 Vdc
Output Impedance	0.1 pada beban 1 Ma
Low Self Heating	0.08℃

In the LM35 design before being connected to the ESP32, an additional module is needed, namely the ads1115 module. The addition of this module is because the ADC from ESP32 cannot measure the voltage from the LM35 sensor precisely.

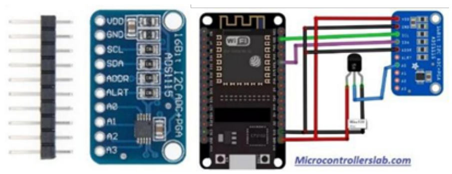

Figure 9 LM35 Wiring Diagram

2.5. MQ135 Sensor Specifications

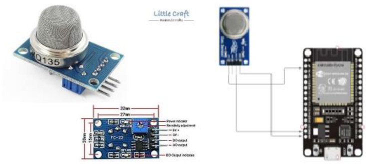

Figure 10 MQ135 Wiring Diagram

The specifications of the MQ135 Sensor are as follows:

Table 4 MQ135 Specification

Symbol	Parameter Name	Technical Parameter	Remark 2
Rs	Sensing Resistance	30KΩ-200KΩ (100ppm NH3)	Detecting concentration scope: - 10ppm-300ppmNH3 - 10-1000ppm Benzene - 10ppm-300ppm Alcohol
α (200/50) NH3	Concentration Slope Rate	≤ 0.65	
Standard Detecting Condition	Temp : 20°C ± 2°C Vc: 5V± 0.1 Humidity: 65% ± 5% Vh: 5V±0.1		
Preheat Time	Over 24 Hour		

2.6. Specification of 1 Channel Relay

Figure 11 Relay 1 Channel Wiring Diagram

The specifications of the 1 channel relay are as follows:

Table 5 Relay 1 Channel Specification

Supply Voltage	3.75V to 6V
Quiescent current	2mA
Current When The Relayis Active	~70mA
Relay Maximum Contact Voltage	250VAC or 30VDC
Relay Maximum Current	10A

2.7. 5V Water Pump

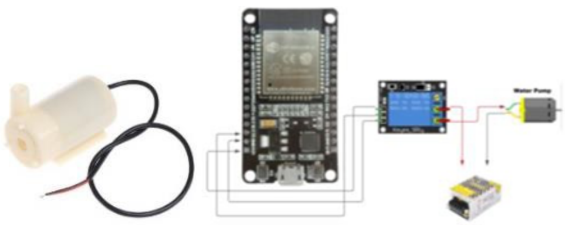

Figure 12 Water Pump Wiring Diagram

The specifications of this water pump are as follows:

Table 6 Water Pump Specification

Input Voltage	DC 3V – 5V
Flowrate	1.2 – 1.6 L/Minute
Operation	0.1 – 0.2 A
Head	0.8 m
Outer Diameter of Water Channel	7.5 mm
Inner Diameter of Water Channel	5.0 mm
Water Inlet Diameter	5.0 mm
Wire Length	200 mm
Size	45 x 30 x 25 mm
Weight	30 gram

2.8. Buzzer

Figure 13 Buzzer Wiring Diagram

The specifications of the buzzer used are as follows:

Table 7 Buzzer Specification

Working Voltage	3v – 12v DC
Resistance	16 ohm
Size	Diameter 12 mm, tebal 8.5 mm
Sound Level	80-85 dB

2.9. Modul SIM900

Figure 14 SIM900

The specifications of the SIM900 Module are as follows:

Table 8 SIM900 Specification

Board Size	85 x 55 x 15 mm(approx)
Color	Blue
GPRS multi-slot class 10/8 GPRS mobile station classB Compliant to GSM phase 2/2+ Class 4 (2 W @ 850 /900 MHz) Class 1 (1 W @ 1800 / 1900MHz)	
Enhanced Commands	SIMCOM AT Commands
Low power consumption	1.5 mA(sleep mode)
Industrial Temperature Range	40 SIM900-GPRS-GSM-STM32-WIFI-DTMf--Shield-Development-Board-Quad-Band-Module-For-A~+85 SIM900-GPRS-GSM-

2.10. Website Design

This fire extinguishing system uses a website as an interface to display measurements from the LM35 Sensor and MQ135 Sensor. The measurement results will be stored in the MySQL database. The following is *the design of the website design of this plant:*

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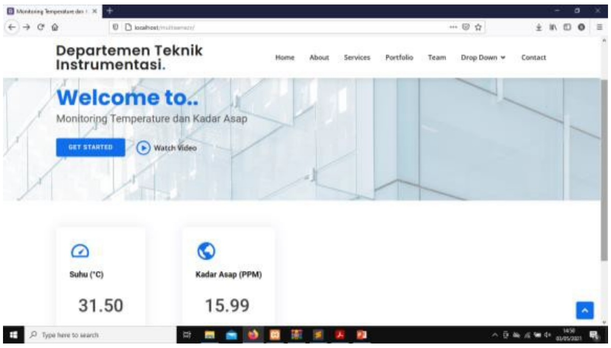

Figure 15 Website Design

3. RESULT AND DISCUSSION

3.1. MQ135 Sensor Testing

Sensor testing is used to determine the performance of the MQ135 Sensor against CO type smoke. MQ135 sensor testing is done by comparing the MQ135 Sensor reading with a standard measuring instrument, namely the AS8700A carbon monoxide meter. Sensor testing is done by giving smoke to the test box for 20 seconds. The following are the test results of the MQ135 Sensor:

Table 9 MQ135 Sensor Testing Result

Time (s)	Standard Instrument (ppm)	MQ-135 Sensor (ppm)	Correction	Error %
30	40	42	2	0.05
60	63	51	-12	-0.19
90	28	37	9	0.32
120	32	36	4	0.125
150	24	26	2	0.083
180	20	25	5	0.25
210	15	19	4	0.266
240	13	16	3	0.230
270	12	14	2	0.166
300	11	13	2	0.18
330	10	11	1	0.1
360	8	10	2	0.25
390	8	10	2	0.25
420	8	10	2	0.25

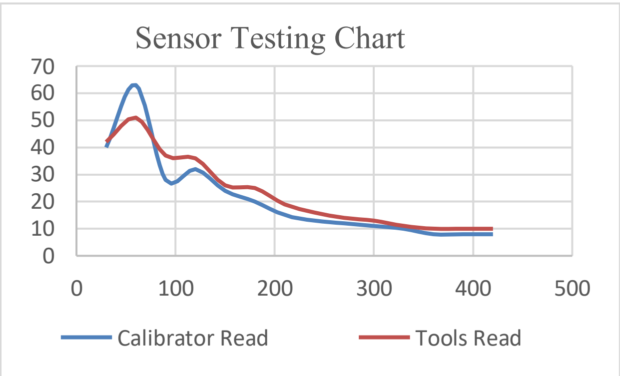

Figure 16 MQ135 Sensor Testing Chart

Based on the table above, it can be seen that the correction of the measurement between the MQ135 Sensor and the AS8700A carbon monoxide meter is quite large. The error resulting from the test is also quite large. The considerable error is due to the Carbon Monoxide Meter reading the increase and decrease in CO levels very quickly than the MQ135 sensor.

- Range: 10 - 51 ppm
- Span: 41 ppm
- Accuracy, A = 0.904 Accuracy (%) = 90.4%
- Sensitivity: 0.072 Ω/ppm
- Linearity

Table 10 MQ135 Input-Output Testing Result

Num	Input (ppm)	Output (Ω)
1	12.81	3.83
2	13.78	3.65
3	15.87	3.33
4	28.71	2.26
5	33.98	2.02
6	35.53	1.97
7	36.67	1.93
8	37.84	1.89
9	38.56	1.86
10	40.79	1.8

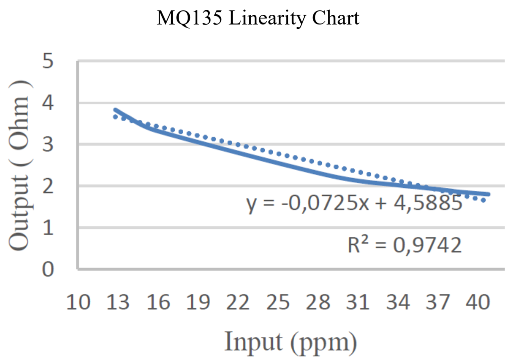

Figure 17 MQ135 Linearity Chart

Based on the graph and data above, it can be seen the linearity graph of the sensor input output and it can be concluded that the greater the ppm value produced by the MQ-135 Sensor, the smaller the output resistance produced by the MQ-135 Sensor.

3.2. LM35 Sensor Testing

For testing the LM35 sensor, a digital thermometer is used to compare the sensor measurement results. Testing is done by measuring the temperature of the mosquito coils. The following are the measurement results of the LM35 Sensor:

Table 11 LM35 Sensor Testing Results

Time(m)	Thermometer Digital (˚C)	Sensor LM35 (˚C)	Correction	Error %
12	32.8	35.7	2.9	8.841463415
24	36.4	37.5	1.1	3.021978022
36	38.6	40.2	1.6	4.14507772
48	41.1	41.7	0.6	1.459854015
60	42.5	43.2	0.7	1.647058824
72	43.3	44.1	0.8	1.847575058
84	44	44.7	0.7	1.590909091
96	44	44.7	0.7	1.590909091
108	43.9	44.7	0.8	1.822323462
120	44.3	47.4	3.1	6.997742664
Average			1.3	3.296489136

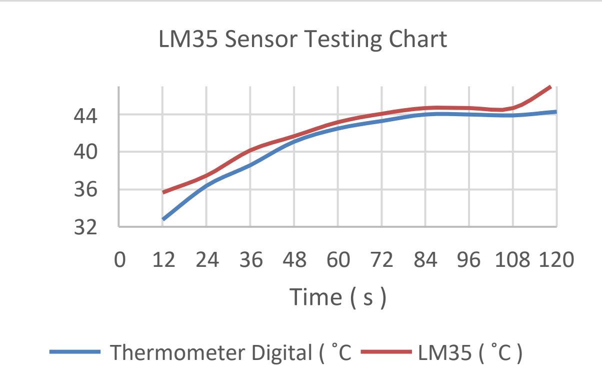

Figure 18 LM35 Sensor Testing Chart

Based on the table above, it can be seen that the LM35 Sensor measurement error from the sensor is 3.3%. When testing measurements it can be seen that the LM35 sensor reads the temperature rise faster than the digital thermometer.

- Range: 35.7 – 47.4 ℃
- Span: 11.7 ℃
- Accuracy, A = 0.968
- Accuracy (%) = 96.8%
- Sensitivity: 0.009 V/℃
- Linearity

Table 12 LM35 Input-Output Testing Result

Num	LM35 Sensor (℃)	Voltage (V)
1	29.4	0.29
2	30.9	0.3
3	31.8	0.31
4	32.1	0.32
5	33	0.33
6	34.5	0.34
7	35.1	0.35
8	36.3	0.36
9	37.5	0.37
10	38.4	0.38

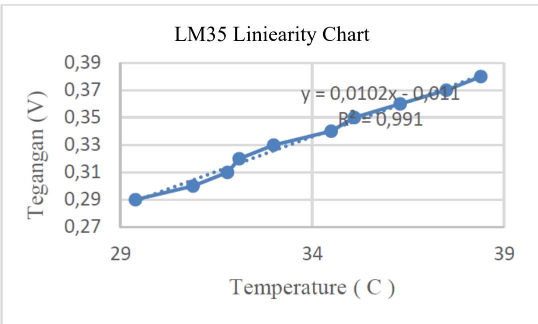

Figure 19 LM35 Liniearity Chart

Based on the data in table 12, it can be seen that the higher the temperature, the higher the voltage issued. So that the linearity graph of the relationship between the input and output of the LM35 Sensor can be known.

3.3. Actuator Testing

Actuator testing is carried out by providing temperature and gas input signals to determine the actuator response to the set point:

Table 13 Relay Response

MQ135 Sensor (ppm)	**LM35 Sensor (°C)**	**Buzzer**	**Relay**
92.55	54	Off	Off
92.86	56	Off	Off
92.86	57	On	Off
93.04	57	On	Off
97.44	57	On	Off
97.37	56	Off	Off
96.36	57	On	Off
95.70	56	Off	Off
101.99	57	On	On
104.45	58	On	On
104	61	On	On
102.71	51	On	Off
102.29	48	On	Off
100.63	45	Off	Off
100.44	42	Off	Off
99.64	41	Off	Off
99.46	38	Off	Off

3.4. LM35 Sensor Specifications

The following are the results of testing the SIM900 Module against the sensor:

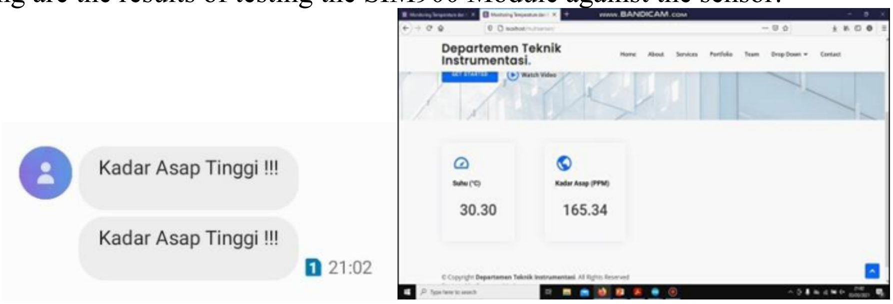

Figure 20 SIM900 Module Response to MQ135 Sensor

Based on the picture above, it can be seen that the sim900 module can send sms when the sensor has reached the set point.

3.5. Automatic Fire Extinguishing System Testing

Testing the system as a whole is done by simulating a fire by giving input to a heat and smoke source. The heat source is given by lighting a candle placed in a box and a source of smoke from burnt paper where these sources are indicators of fire. In addition to testing the sensor response to input, testing the system as a whole is also used to determine the response of the actuator, namely the buzzer and relay to the predetermined set point and also the SIM900 Module in providing notification if there is an indication of fire. The sensor measurement data is displayed in the website interface and stored in the mySQL database.

Figure 21 Automatic Fire Extinguisher System Testing

Table 14 The Overall Testing Results of the Fire Extinguishing System Prototype

Sensor MQ-135 (PPM)	Sensor LM35 (°C)	Buzzer	Relay	SMS
20.83	33	OFF	OFF	OFF
25.12	33.9	OFF	OFF	OFF
47.88	36.6	OFF	OFF	OFF
39.83	37.5	OFF	OFF	OFF
118.11	38.4	ON	OFF	ON
188.12	37.8	ON	OFF	ON
165.34	37.2	ON	OFF	ON
119.56	37.2	ON	OFF	ON
70.41	45	OFF	OFF	OFF
67.93	54.6	OFF	OFF	OFF
63.22	55.8	OFF	OFF	OFF
67.12	63	ON	OFF	ON
57.08	82.5	ON	OFF	ON
223.59	61.6	ON	ON	ON
121.77	58.8	ON	ON	ON

Based on the system testing table above, it can be seen that this system is running well. The LM35 Sensor and MQ135 Sensor can respond to heat and smoke sources well so that when one of the sensors, the LM35 Sensor, exceeds the set point of 57 °C and the MQ135 Sensor reaches 101 ppm, the buzzer will provide a warning notification. If the temperature and smoke levels have exceeded the set point, the relay will be active and the pump will be active and the spray nozzle will extinguish the heat source and smoke until conditions become normal. In the test, it can be seen that the sim module provides sms notification right when there is an indication of fire. The website as an interface display also displays the measurement results properly and the system test data can be stored and monitored in the MySQL database.

Figure 22 SMS Notification

4. CONCLUSION

This fire extinguishing system prototype is designed using software, namely the LM35 sensor circuit, MQ135 sensor, actuator, controller, sim900 module, and website. The hardware design is a system test box. The software design results are placed on the panel box on the left side of the prototype, and water is used as an extinguishing medium on the right side. This prototype is built through hardware, software design so that the prototype can run well and be displayed on the website. This system is built using lm35 sensors and mq135 sensors where these two sensors can measure temperature and smoke levels in real time. Testing the performance of the LM35 sensor is done by providing a heat source from mosquito coils and it can be seen that the LM35 Sensor can respond to temperature increases properly. MQ135 Sensor testing is done by providing smoke, and based on measurement data it can be seen that the MQ135 Sensor can detect smoke very quickly.

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