Design and Build a Hazardous Gas Monitoring Device (CO, CO_2, CH_4) Upon Cigarette Smoke in an Enclosed Space Based on Arduino Uno and GSM SIM 900 A

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Abstract
Increasing cigarette usage in daily activities contributes to air pollution caused by cigarette smoke, which is a factor in the onset of numerous respiratory ailments. This research intends to develop a technology that will simplify users' monitoring of hazardous gases (CO, CO_2, and CH_4) levels in a room using Arduino Uno and GSM SIM 900A with MQ-4, MQ-9, and MQ-135 sensors. The method comprises hardware design, software design, and testing. The research was performed twice. The testing gas employed in this research is cigarette smoke gas. The red LED, fan, and buzzer turn on when the CH_4 gas level reaches 250, the CO level reaches 300, or the CO_2 gas level reaches 2000. A GSM SIM 900A sends a short message through SMS to the user's device. The initial test results were acquired in the 240th second when CH_4 gas reached 299.84 299.84 ppm (hazardous), CO reached 310.06 ppm 299.84 ppm (hazardous), and CO_2 reached 291.45 ppm (safe). The second test revealed that at 160 seconds, CO_2 reached 308.98 ppm (hazardous), CO reached 161 ppm, and CH_4 reached 315.6 ppm (hazardous). Three media specialists conducted validation to determine the viability. The average category rating for the validation test findings was 95.5% so that the instrument can monitor the room's gas levels.

Keywords: *Arduino Uno, Sensor MQ-4, Sensor MQ-9, Sensor MQ-135, GSM SIM 900A.*

Abstrak
Dalam aktivitas sehari-hari penggunaan rokok semakin meningkat yang mengakibatkan pencemaran udara karena asap rokok yang dihasilkan, hal ini sebagai pemicu timbulnya berbagai penyakit pernafasan. Penelitian ini bertujuan untuk membuat alat untuk mempermudah pengguna memonitoring kadar gas berbahaya (CO, CO_2, dan CH_4) di dalam ruangan, menggunakan sensor MQ-4, MQ-9, dan MQ-135 berbasis Arduino Uno dan GSM SIM 900A. Metode yang digunakan adalah perancangan perangkat keras, perancangan perangkat lunak, dan pengujian. Penelitian dilakukan dua kali pengujian. Gas yang digunakan untuk uji coba dalam

penelitian ini adalah gas yang dihasilkan dari asap rokok. Jika nilai kadar gas CH_4 sudah mencapai 250, CO mencapai 300 atau gas CO_2 mencapai 2000 maka LED merah, kipas dan buzzer aktif serta SMS dikirim ke nomor pengguna melalui pesan singkat oleh GSM SIM 900A. Hasil pengujian pertama didapatkan pada detik ke-240 gas CH_4 mencapai 299.84ppm (berbahaya), CO mencapai 310.06 ppm (berbahaya), dan CO_2 mencapai 291.45 ppm (aman). Pengujian ke dua didapatkan pada detik ke-160 gas CH_4 mencapai 315.6 ppm (berbahaya), CO mencapai 161 ppm (aman), CO_2 mencapai 308.98 ppm (berbahaya). Validasi dilakukan oleh tiga orang ahli media untuk menilai kelayakan. Hasil uji validasi didapatkan nilai rata-rata sebesar 95,5% dengan kategori sangat baik. Sehingga alat dapat digunakan untuk memonitoring gas di dalam ruangan.

Kata Kunci: *Arduino Uno, Sensor MQ-4, Sensor MQ-9, Sensor MQ-135, GSM SIM 900A.*

1. Introduction

Every day, humans require sufficient oxygen for activity, absorption of food, immune strengthening, and elimination of some metabolic pollutants. The air we breathe daily should be free of pollutants and poisons, including CO, CO_2, and CH_4 gases. Daily increases in industrial plants, power plants, and motorized vehicles that emit airpollution have led to technological advancements. As a result, the air we breathe becomes contaminated, threatening our health and the health of the ecology around us. (J. Abidin et al.,2019)

In reality, the air we breathe is now highly polluted, particularly in metropolitan areas, which use, on average, modes of mobility that necessitate fossil fuels for every activity and land use change. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are three gases that can be created by such activity and whose concentrations are rising (Y. Abidin, 2021). This includes Carbon Monoxide (CO) gas created when transportation fuelsare burned. Global warming is not primarily caused by human activity; it can also be caused by natural events such as forest fires resulting from lengthy droughts, volcanic eruptions, and other phenomena (anthropogenic).

Two sorts of activities generate CO_2: natural (natural) and anthropogenic (inducedby humans), including waste disposal, transportation, and domestic electrical energy use. Anthropogenic CO_2 emissions (CO_2 created by human activities) have relatively high. Concentrations disturb the air balance system and ultimately impair the environmentand human welfare. (Dicha K. H. Ruwayari, Veronica A, Kumurur, 2020).

Carbon monoxide (CO) is an undiscovered poisonous gas that cannot be seen or smelled and whose presence is, therefore, unknown. Many people attribute carbon monoxide poisoning to automobiles, not well-constructed space heaters. Carbon monoxide exposure can cause toxicity to the heart and central nervous system. Also impacted by carbon monoxide are infants born to pregnant moms. Headache and nausea are indicators of moderate toxicity at concentrations below 100 ppm. Carbon monoxide (CO) is an odorless gas, and concentrations as low as 667 parts per million (ppm) can cause 50% of the body's hemoglobin to convert into carboxyhemoglobin (HbCO). (Taneo et al., 2021). This element is produced from the incomplete combustion of carbon. Toxic carbon monoxide exists. Carbon monoxide concentrations in cigarette smoke range from 3 to 6%. (Abdullah & Suhendi, 2019)

In addition to carbon dioxide (CO_2), the primary contributor to global warming, methane gas (CH_4) also makes a substantial contribution. (Artiningrum, 2017), also in daily life, particularly indoors. Air pollution has numerous causes, including cigarette smoke, which is breathed and endangers the health of others in the room.

About 5% of all incidents of stroke are attributable to tobacco usage. Over 40 million children in Indonesia between 0 and 14 are constantly exposed to secondhand smoke. They acquire weakened lungs and are more susceptible to respiratory infections, including pneumonia, bronchitis, and asthma. By 2030, it is anticipated that smoking will cause 10 million deaths yearly and at least 70 per cent of all deaths indeveloping nations. Tobacco smoking can cause chronic bronchitis, acute bronchitis, pneumonia, asthma, emphysema, and lung cancer.

Data from the 2018 Basic Health Research (Riskesdas) indicate that 24.3% of the population aged ten and over in Indonesia are daily smokers, and 4.6% are occasional smokers, representing 28.9%. West Java has a total prevalence of 32%, with 27.1% of the population classified as daily smokers and 4.9% as occasional smokers. Working smokers are more prevalent in West Java than non-working smokers and students. Male smokers are more prevalent in West Java than female smokers. The increased prevalence of respiratory disease among smokers is directly attributable to their smoking habit. These results are published in (Aliya Salsabila & Yuniarti, 2022). Despite several cautions, smoking rates rose between 2014 and 2019 among men and women, from 33.9% to 35.5% for men and 2.5% to 2.9%for women. (UNICEF Indonesia, 2021).

The Indonesian government has published a law on the security of chemicals that are addictive, including information on cigarettes that is presented in the package in the form of images, text, a mix of both, or other formats (Http://Www.Bphn.Go. Id/, 2012) Due to the rising number of active smokers in the country and the severity of the risks involved. Although much effort has been expended, it appears to be less effective than it formerly was. Since the 1970s, the number of smokers has remained largely stable after adjusting to the population increase. (Rachmawati et al., 2018).

As a result of this issue, the government is contemplating the creation of a dedicated smoking area within the public building to protect the health and safety of everyone who uses this structure. A fan is vital for maintaining the room's air quality. The fan is one of the most prevalent machineries in the manufacturing sector. Exhaust fans are employed in nearly every industry to aid in production. The exhaust fan pulls in outside air and exhausts stale inside air to cool the space. In addition, the amount of air supplied into the room can be adjusted by modifying the fan speed. The room should be well-aired to facilitate the constant interchange of stale air with outside air for optimal health (Hipni et al., 2019). Instead, they devised a manually operated fan whose rotational speed was locked at a predetermined value to maintain a pleasant room temperature regardless of actual air conditions or ventilation needs.

Therefore, the author designed a technology that can identify and monitor the presence of potentially hazardous gases automatically, which utilizes MQ-4, MQ-9, and MQ-135 sensors based on an Arduino Uno and GSM SIM 900A in order to make it simpler for users to monitor levels of dangerous gases (CO, CO_2, and CH_4) in the room.

Carbon dioxide (CO_2) detection is possible with the MQ-135 sensor (Lahal & Suharyanto, 2020; Tahir et al., 2020); With the MQ-4 sensor, methane gas (CH_4) may be detected. (Maharani, 2020); and the MQ-9 sensor (which can detect carbon monoxide gas) (Lahal & Suharyanto, 2020; Tahir et al., 2020). The GSM SIM 900A will transmit the user an SMS/phone alert when the gas level in the room reaches a hazardous level without requiring the user to look at the screen. (Adi et al., 2019).

2. Method

This research employs testing, software design, and hardware design as approaches. Designing the hardware is the initial stage. The system components are assembled into a design at this step. Non-filtered cigarettes were the kind utilized in the experiment. As soon as cigarette smoke contacts any of the three sensors (MQ-4, MQ-9, and MQ-135), the sensor transmits data in the form of a gas level value to the Arduino Uno control system, which then tells the LCD to show the gas level value. If the temperature has not reached a hazardous level, a green LED will illuminate to indicate that it is safe. The system will inform GSM SIM 900A to transmit a short SMS message to the user with the message "Danger; there is a gas level spike" and the gas level value at that moment ifthe gas level reaches a dangerous threshold, which will operate the red LED, buzzer, and fan. The following block diagram illustrates the hardware architecture.

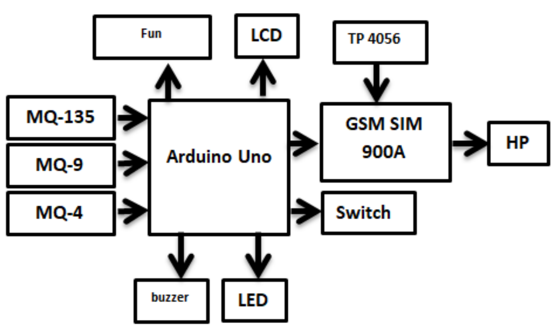

Figure 1. Block Diagram of the Gas Monitoring System for CO, CO_2, and CH_4

The following are the main elements of the hardware design:

2.1 Microcontroller

Arduino is a simple input/output board that serves as an open-source physical computing platform. PCP is envisioned as a physical system that can identify and respond to circumstances using software and hardware. The microcontroller board called Arduino Uno, which is utilized in this research, includes 14 digital I/O pins (six of which are PWM pins), six input pins, and a programmable digital signal processor. It is powered by an Atmel AVR ATMEGA328 microprocessor. (Sasmoko, 2021).

Figure 2. Arduino Uno Display

2.2 Sensor MQ

There are MQ-4, MQ-9, and MQ-135 sensors used. The configuration of the MQ sensor is displayed in the illustration.

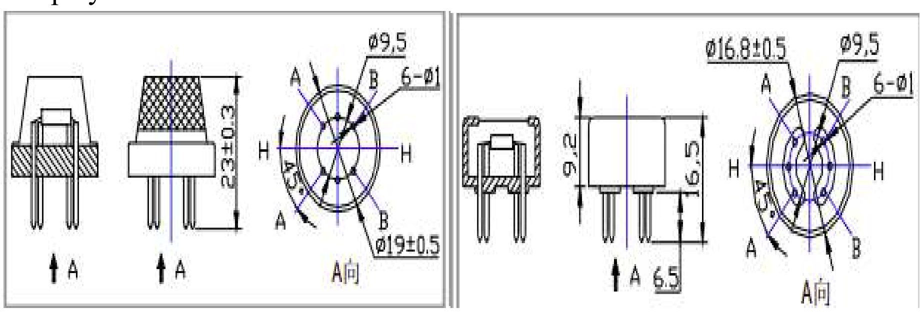

Figure 3. MQ Sensor Configuration

The MQ gas sensor comprises of an AL2O3 micro-ceramic tube, a Tin Dioxide (SnO_2) sensitive layer, measuring and heating electrodes, and a plastic and stainless-steel mesh scale, as illustrated in Figure 1. (Configuration A or B). The heater generates an environment where even the most sensitive components can do their duties. Four of the six pins on the MQ envelope (4, 9, 135) are utilized for signal pickup, while the remaining two provide heating current. (Electronics, 2015; Hanwei Electronics, 2018; Olimex, 2013).

2.3 Module GSM SIM 900A

Figure 4. Module GSM SIM 900A

GSM SIM900A is capable of functioning as the system's receiver. GSM SIM900A will acquire instructions from Arduino, then process the data received from Arduino so that it may be transmitted as an SMS. (Short Message Service) (Gsm et al., 2018)

2.4 LCD size 16x2

Figure 5. LCD I2C 16X2

The maximum number of characters that a 16x2 I2C LCD is able to display is 32, with each line displaying 16 characters. This device's LCD is designed to display information regarding water distance

2.5 Module TP 4056

Figure 5. LCD I2C 16X2

The maximum number of characters that a 16x2 I2C LCD is able to display is 32, with each line displaying 16 characters. This device's LCD is designed to display information regarding water distance

2.6 LED

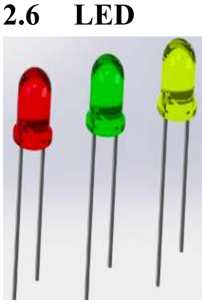

Figure 7. LED

LEDs are employed for the control system; green and red LEDs are used according to their function, with green indicating that the air is safe and red indicating that it is hazardous.

2.7 Buzzer and Fan

Buzzer serves as an alarm, signalling both cautions and alerts. The fan is utilized to eliminate gas and introduce fresh air into the room.

Figure 8. Buzzer

Figure 9. Fan

The second stage is software design, which takes the form of computer programs that regulate how the tool moves. C is the programming language used with the Arduino IDE application.

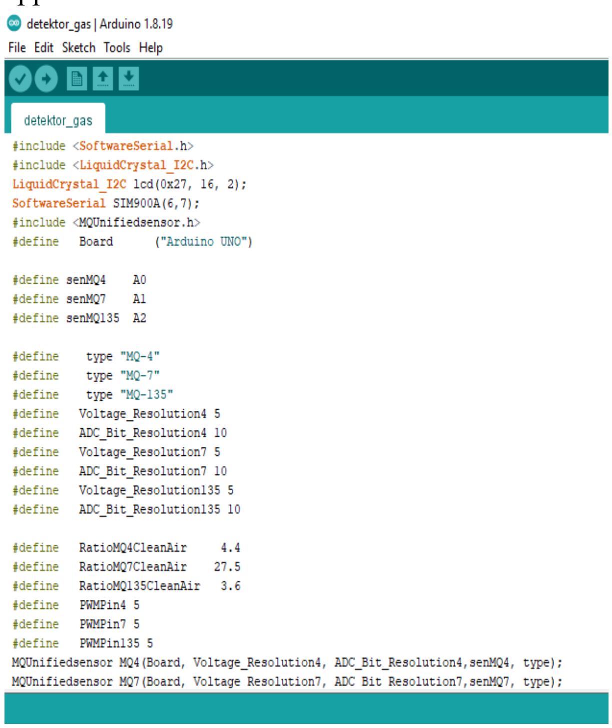

Figure 10. Software Program

The design of the program consists of a working system derived from the design of the tool, as depicted in the *flowchart* (Figure 11).

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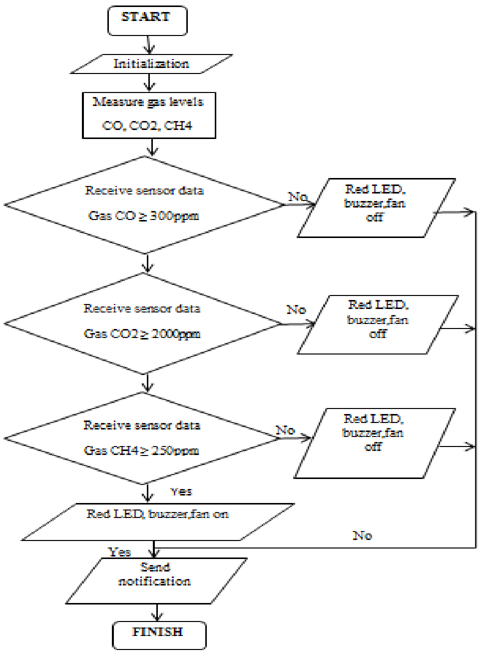

Figure 11. Flowchart of CO, CO_2, and CH_4 Monitoring Equipment

The operational system of the CO, CO_2, and CH_4 hazardous gas monitoring instrument for cigarette smoke begins with the device's initialization. The instrument's operating system will initiate by reading sensor data; then the sensor sends the data to the Arduino, the Arduino sends the data to the LCD for display, and if the gas level surpasses the predetermined threshold, the system will automatically operate the red LED, buzzer, and fan, as was done in his research. (Hamdani, Dedy. Handayani et al., 2019).

Additionally, the system will inform GSM SIM 900A to transmit an alert to the user or the officer responsible for monitoring the room. Determining whether the tool is suitable for monitoring the room for dangerous gases (CO, CO_2, CH_4) using a Likert scale-based questionnaire with the following score criteria.

Table 1. Criteria for Evaluating Media Expert Surveys for Validation Tests

Value	Statement
1	Very Unkind (STB)
2	Not Good (TB)
3	Good (B)
4	Excellent (SB)

Then, the data collected from the distribution of the questionnaire will be analysed using the following formula. 100% was the highest possible score:

$$X = \frac{\Sigma x}{n} \quad (1)$$

Information: X = Average value
Σx = Total score of assessment answers
n = Number of ratters (Diah & Nita, 2018)

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In accordance with the following score interpretation: 0%-25% = sangat kurang baik; 26%-50%= kurang baik; 51%-75%= baik serta 76%-100%= sangat baik (Sari et al., 2020).

3. Result and Discussion

The third phase involves testing with the implementation of the gas monitoring tools (CO, CO_2, and CH_4) that have been created.

3.1 Monitoring of Gas Realization (CO, CO_2, and CH_4)

As a result of the design work, a tool that can control harmful gases (CO, CO_2, and CH_4) has been produced. This tool is more straightforward than the previous one because it monitors and recovers air automatically without needing the user to be present. Instead, it follows instructions from a coding system that consists of both existing and modified coding. Table 2 displays the principal elements that go into the creation of the tool and Figure 9 displays the tool is finished form. Principal components of the instrument is showed at Table 2.

Table 2. Principal Components of the Instrument

Component	Sum
Arduino Uno	1
Sensor MQ-4	1
Sensor MQ-9	1
Sensor MQ-135	1
GSM SIM 900A Module	1
Lcd	1
TP 4056 Module	1
Fan	1
Buzzer	1
Red LED	1
Green LED	1

Figure 12. Implementation of CO, CO_2, and CH_4 Gas Monitoring Equipment

When the user connects the USB connection to the laptop and turns on the gadget, voltage 5V isalso required. Then the LCD appears "KALIBRASI SENSOR CO-CO_2-CH_4", "PENDETEKSI GAS", "Kalibrasi MQ-135 Kalibrasi MQ-4 Kalibrasi MQ-9", "SIM 900A SIM 900A SIAP" The green and red LEDs flash alternately to signal that the system is working properly.

Figure 13. Green and Red LEDs Flash Alternately

3.2 Sensor Evaluation Based on Gas Level Measurements in the Box/Room

The measurements were performed using a sample of smoke from one cigarette. Tables 3 and 4 show the results of the second measurement using a sample of smoke from two cigarettes.

Table 3. The Results of the First Gas Measurement with 1 Cigarette per 20 Seconds

Time (seconds)	Gas Content (ppm)			Information
	CH_4	Co.	CO_2	
1	12.10	12.1	12.15	Safe
20	18.51	12.8	37.58	Safe
40	30.01	19.2	54.75	Safe
60	66.32	44.0	70.15	Safe
80	88.62	75.1	98.47	Safe
100	109.2	100.0	106.61	Safe
120	135	125.0	130.57	Safe
140	156.5	145.0	143.84	Safe
160	214.4	176.0	137.10	Safe
180	206.8	212.0	185.15	Safe
200	233.1	217.0	197.70	Safe
220	247.2	231.0	219.94	Safe
240	299.84	310.06	291.45	Dangerous

Table 4. The Outcome of The Second Test with 2 Cigarettes per 20 Seconds

Time (seconds)	Gas Content (ppm)			Information
	CH_4	Co.	CO_2	
1	10.70	5.73	9.42	Safe
20	25.39	13.3	40.04	Safe
40	80.30	35.7	74.09	Safe
60	124.9	68.4	118.29	Safe
80	124.57	84.8	104.57	Safe
100	150.9	84.8	130.14	Safe
120	163.2	86.7	163.31	Safe
140	204.3	112.0	210.42	Safe
160	315.6	161	308.98	Dangerous

The findings of gas level measurements performed in the first experiment using a sample of smoke from 1 cigarette and the second test using a sample of 2 cigarettes left in a closed space/box that measured 40 cm long, 25 cm wide, and 25 cm high. When the level of CH_4 gas hits 250 parts per million, it is deemed harmful (Raharjo et al., 2018), CO gas levels approach 300 ppm (Badan Pengendalian Dampak Lingkungan, 1997), or CO_2 reaches 2000 ppm (Nugroho et al., 2021). This maximum value is determined by the Literature mentioned. In the first trial, before being exposed to cigarette smoke, the typical levels of Methane (CH_4), Carbon Monoxide (CO), and Carbon Dioxide were 12.10ppm, 12.1ppm, and 12.15 ppm, respectively (CO_2). After being exposed to cigarette smoke, the assessment is performed every 20 seconds. With a room volume of 28.125m^3, the gas levels detected reach the maximum threshold specified in Table 2, where 240 CH_4 gas reaches 299.84 ppm (dangerous), CO reaches 310.06 ppm (dangerous), and CO_2 reaches 291.45 ppm (safe). The same thing occurred during the second measurement using a sample of two cigarettes. Prior to being exposed to cigarette smoke, the room's usual values for methane (CH_4), carbon monoxide (CO), and carbon dioxide (CO_2) were 10.70 ppm, 5.73 ppm, and 9.42 ppm, respectively (CO_2). After 160th second expo to cigarette smoke, the concentration of CH_4 becomes 315.6 ppm (hazardous), Carbon Monoxide (CO) exceeds 161 ppm (safe), and Carbon Dioxide (CO_2) exceeds 308.98ppm (dangerous). Thus, the systemtriggers the buzzer, red LED, and fan and delivers a brief SMS message to the user. This is because the amount of CO and CH_4 gases is contained in cigarette smoke produced by the increasing speed of smoke in the room.

3.3 GSM SIM 900A Module Trial

The testing module can work efficiently (dangerous) when the gas concentration reaches the criterion. In this test, the GSM SIM 900A module can read the gas concentration and send the user an SMS carrying the "Danger" alert. There was an increase in the concentration and value of CO, CO_2, and CH_4 gases.

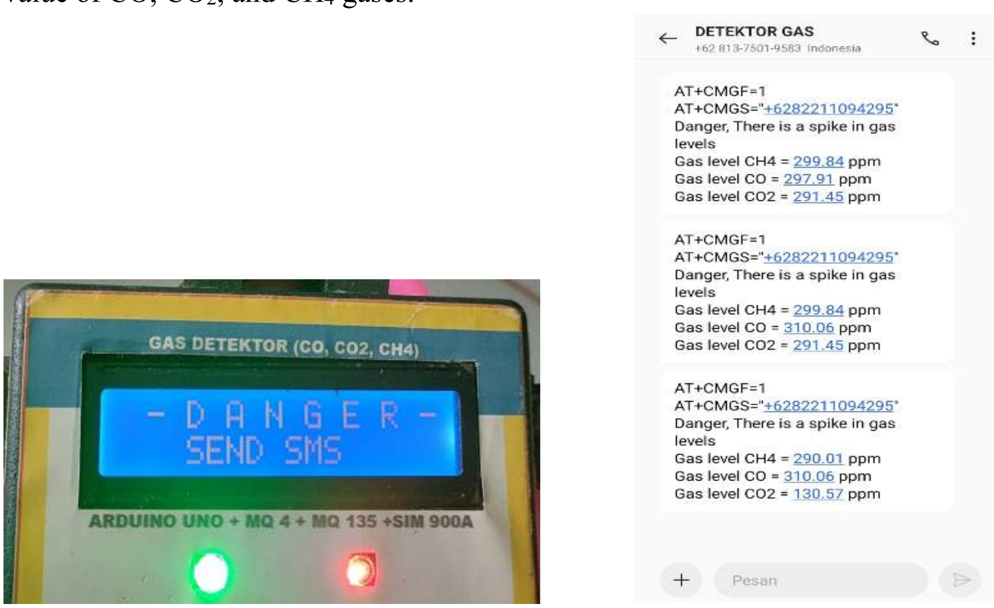

Figure 14. Information transmitted by GSM Module SIM900A

Consequently, the module is deemed operational, and the user can determine the gas surge value. At the moment of testing, a green LED illuminates to indicate that the air is safe to breathe. When hazardous air is detected, a red LED illuminates, a buzzer sounds, and the fan goes on.

After completing the testing process, three media experts were consulted for additional validation and a test of viability. With a total of 16 questions according to the assessment rubric which is loaded based on 4 aspects of the assessment.

Table 5. The Outcomes of Expert Validation of CO, CO_2, and CH_4 Monitoring Instruments

No	Assessment Aspects	Validators			Average (%)	Criterion
		Validation 1	Validation 2	Validation 3		
1.	Tool Efficiency	87,5	87,5	100	91,7	Excellent
2.	Tool Durability	83,3	100	100	94,43	Excellent
3.	Aesthetic	100	83,3	100	94,43	Excellent
4.	Tool Components	100	100	100	100	Excellent
Average Validation Value (%)		**92,7**	**92,7**	**100**	**95,14**	**Excellent**

Based on three validators' outcomes of media expert validation, a mean value of 95.14% with excellent criteria was determined. According to the evaluation criteria of (1) Tool Efficiency, (2) Tool Durability, (3) Aesthetics, and (4) Tool Components (Sutanto,2011). The authors conclude that a monitoring tool for harmful gases CO, CO_2, and CH_4 in cigarette smoke in a closed room based on Arduino Uno and GSM SIM 900A can be used to assist active smokers in controlling the levels of CO, CO_2, and CH_4 in it.

4. Conclusion

The validation of the feasibility test yielded an average of 95.14 per cent with excellent criteria based on the testing findings, indicating that the tool functions well and can be used to achieve the aim. In addition, the instrument can monitor toxic gases (CO, CO_2, CH_4) in an enclosed space.

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