

DESIGN OF THE POLLUTION GAS CARBON MONOXIDE (CO) MONITORING SYSTEM BASED ON MICROCONTROLLER

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INTRODUCTION

Air pollution is a threat to the ecosystem and quality of life on earth because it affects our daily activities. Resulting in a harmful effect on human well-being that is changing the health of the exposed population [1]. Therefore it is essential to monitor pollution to reduce and control it. According to PP No.29 of 1986, air pollution can also be interpreted as changes in the air structure by human activities or by natural processes. The air quality becomes less or no longer able to function according to its use. These emissions come from pollution sources, mainly from transportation, where almost 60% of the pollutants produced consist of carbon monoxide (CO), and about 15% consists of hydrocarbons (HC). Air quality monitoring systems can use sensors with low cost and power. Data from sensors on Arduino can be collected from various places and stored, plotted graphically, and easily updated [2]. Air quality measurement system using Arduino Uno microcontroller and four low-cost sensors to measure the concentration of carbon monoxide (CO), ground surface ozone (O₃), and particulate matter (PM10 & PM2.5) in the air and convert readings into API values [3].

The air pollution monitoring system is designed to monitor and analyze air quality in real-time and log data to remote servers, keeping data updated via the internet. The air quality measurements are taken based on the Parts per Million (PPM) metric [4]. The design included several devices, mainly: Arduino Microcontroller, MQ-2 Gas Sensors, and the current regulator circuit. On the normal gas levels of the air, the results show that there is a big difference in the gas levels of both gases (LPG and CO) obtained from several tests and circuit runs [5].

An Environmental Air Pollution Monitoring System (EAPMS) for monitoring the concentrations of major air pollutant gases has been developed, complying with the IEEE 1451.2 standard. This system measures concentrations of gases such as CO, NO₂, SO₂, and O₃ using the semiconductor sensors. The STIM (smart transducer interface module) was implemented using the analog devices' ADuC812 micro converter [6].

Carbon monoxide is a flammable gas and very poisonous to humans. In the WHO World Health Organization report, estimates of air pollution in big cities have exceeded the tolerance threshold [7]. This research will conduct a design to monitor the level of carbon monoxide (CO) gas concentration using an MQ-135 sensor based on the Arduino Uno microcontroller [8]. This system will monitor and analyze carbon monoxide gas in real-time and display it to the LCD in parts per million (ppm).

METHOD

The method in this study has several stages:

A: The design phase of the tool is making; the electronic device circuit on the PCB (shield board), programming the device, and making the design of the machine chasing.

B: Testing and implementation phase of the tool includes: MQ-135 sensor calibration with standard comparison instruments, as well as conducting fittings and assembling.

System design for hardware (hardware) in the form of electronic design and mechanical design of the system, while for software (software) by making programs for sensor readings and display design (display) so that the operation can work well. FIGURE 1 Overall system block diagram.

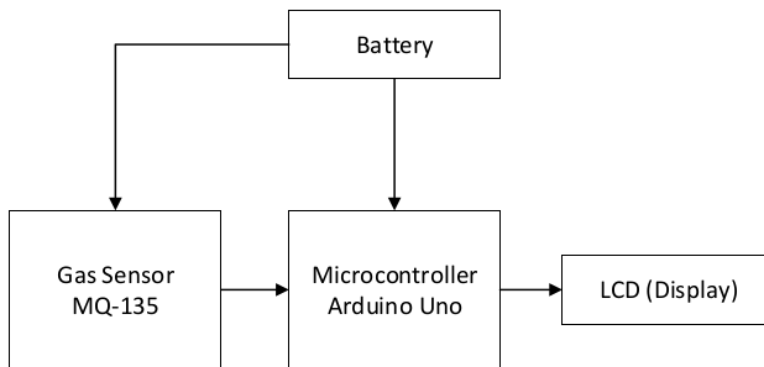


FIGURE 1. The System Block Diagram

Hardware Design

The hardware design includes the creation of an Arduino Uno schematic circuit design that is integrated with all input and output devices in the form of a shield board and tool casing design.

Shield board

The shield board was explicitly created for Arduino Uno to communicate with input and output devices. The input devices consist of: a battery, a step-down circuit, a push button, and an MQ-135 gas sensor. While the output device includes a 4.2 inch TFT LCD Touch Screen.

Tool casing design

The design of tool casing uses acrylic as its raw material with varying thicknesses. The casing design consists of the top layer, middle layer, and bottom layer. The design is shown in FIGURE 2-5.

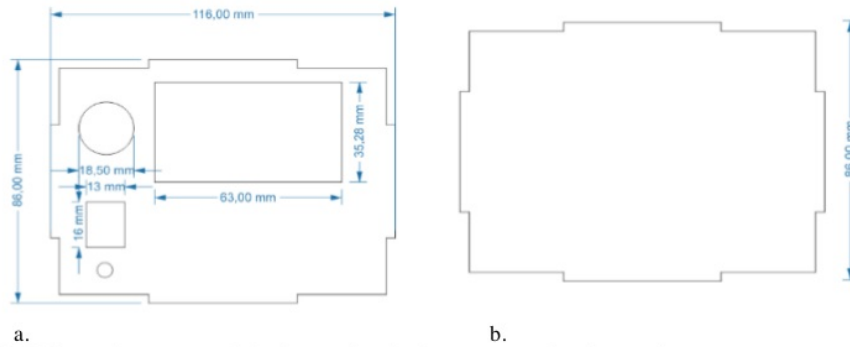


FIGURE 2. a. The Upper Tool Casing Design, b. The Lower Tool casing Design

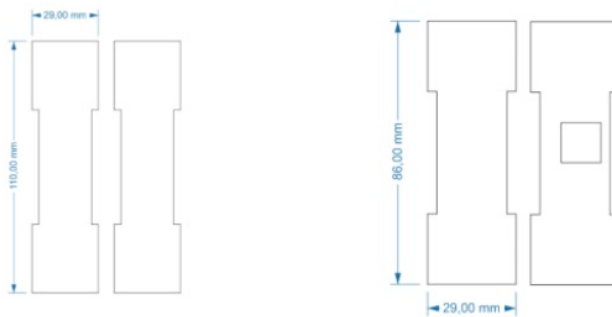


FIGURE 3. Side Casing Tool Design

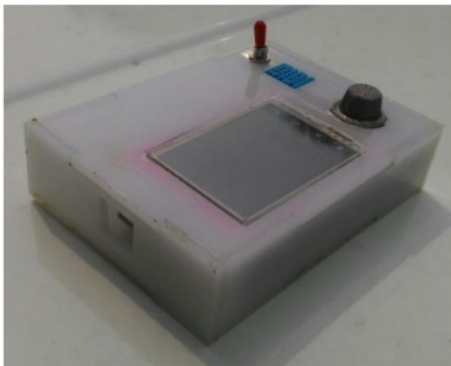


FIGURE 4. The Results of The Design of The Tool Casing

Software Design

In this research, the software as a collection of commands so that the microcontroller can work well. To do programming on Arduino UNO, which uses Arduino IDE software whose role is to write programs, compile programs into binary code and upload programs to the

microcontroller memory. To program the Arduino board with the programming language of Arduino IDE (C / C ++).

Transfer data with integer and float types

In designing this tool used several variables with integer and float data types to store the measurement results from the sensor, the program code as follows:

```
15  
int readIndex = 0  
int total = 0;  
int average = 0;  
float BacaSensor = analogRead(A0);  
float volt=(BacaSensor*5)/1023;
```

Display design

Display design (display) so that all data processed can be displayed with an elegant, dynamic, and interactive visualization. The screen on the show uses the Arduino IDE program too, the program code is as follows:

```
9  
lcd.setCursor(0,0);  
lcd.print("Kadar CO: ");  
lcd.setCursor (10,0);  
lcd.print(average);  
if(average<=25){  
lcd.setCursor(4,1);  
lcd.print("NORMAL");
```



FIGURE 5. The LED Display Design Results

Data retrieval

Data retrieval is done simultaneously with testing each component. Following is the procedure for collecting data from each element.

MQ-135 sensor data retrieval

They are testing the MQ-135 gas sensor to calibrate the sensor with a standard carbon monoxide (CO) gas gauge. Testing by measuring CO gas concentration together with the

position of the sensor/tool and the calibration are placed close together in a closed room [11,12]. The data taken is the value of the ADC (Analog to Digital Converter) and ADC conversion to the output voltage (V_{out}) from the reading of the MQ-135 gas sensor.

Calibration process by measuring the value of the ADC sensor with CO gas in the range of 100-300 ppm. Measurement of ADC values using the Arduino IDE program so that the measured ADC and V_{out} values can be displayed on the LCD of the Tool. The ADC value is used as data to find a mathematical model of the relationship of R_s / R_o with ppm CO gas, so that it can calculate the concentration of CO gas in parts per million (ppm).

RESULT AND DISCUSSION

The results of the entire design of the air content monitoring system in FIGURE 5 display that serves to provide information on the measurement results of the detection value of CO levels read by the tool and humidity as well as temperature in the form of a reference to calculate the level of pollution contained in the surrounding environment

Here are the results of the MQ-135 sensor ADC test on changes in the CO gas concentration of the comparison instrument. To calibrate the MQ-135 sensor by using a standard CO gas gauge. This test is carried out in a confined space together with carbon monoxide (CO) gas concentration measuring instrument "Krisbow KD09-224 Carbon Monoxide Meter," which functions as a calibrator or comparison instrument.

TABLE 1. MQ-135 Sensor ADC Test Results

Comparison Instrument (calibrator) (ppm)	ADC Sensor Measurement Results			Average ADC
	1	2	3	
100	351	348	352	350.333
150	362	386	475	407.667
200	440	430	428	432.667
250	475	471	460	468.667
300	521	518	524	521.000

To find out the value of CO gas concentration in units of parts per million (ppm) is to take some R_s data (MQ-135 sensor resistance at different gas concentration levels) ADC data is then processed to obtain values from V_{out} , R_s and R_s / R_o :

$$R_s \text{ 100 ppm CO} = R_o \quad (1)$$

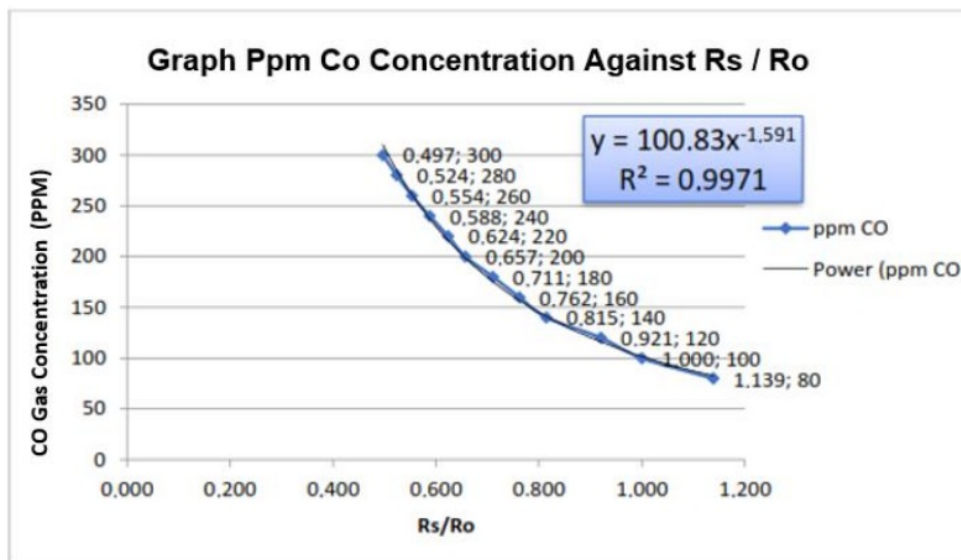
$$V_{out} = \frac{V_{cc} \cdot R_L}{R_s + R_L} \quad V_{cc} \quad (2)$$

$$R_s = \frac{V_{cc} \cdot R_L}{V_{out}} - R_L \quad (3)$$

TABLE 2. Calculation Results for V_{out} , R_s and R_s/R_o

Comparison Instrument - calibrator (ppm)	Average ADC	V_{out} (Volt)	R_s (k Ω)	R_s/R_o (k Ω)
100	348.513	1.714	19.114	1.000
120	371.472	1.821	17.587	0.927
140	401.130	1.948	15.543	0.814
160	418.413	2.037	14.569	0.768
180	425.554	2.122	13.588	0.714
200	450.836	2.220	12.572	0.655
220	464.552	2.276	11.920	0.621
240	480.864	2.352	11.241	0.581
100	348.513	1.714	19.114	1.000
120	371.472	1.821	17.587	0.927
140	401.130	1.948	15.543	0.814

Based on the data in TABLE 2, the value of R_s at the time of CO 100 ppm gas concentration was 19.114 k Ω , with EQUATION (2), the amount of R_o is 19.114 k Ω .

FIGURE 6. Graph ppm Co Concentration Against R_s/R_o

From the graph, the results of the trendline power regression obtained equation.

$$Y = 100.83 (x^{-1.591}) \quad (4)$$

with:

Y = value of CO gas concentration (part per million)

$$X = R_s / R_o$$

Y value to convert ADC microcontroller into ppm sensor value, to get the amount of CO gas concentration on the sensor in units of ppm (parts per million) using EQUATION 4.

TABLE 3. The Results of CO Gas Concentration Testing

No	Comparison Instrument (calibrator) (ppm)	MQ-135 (ppm)	Δ (ppm)	Error (%)
1	100	101.793	1.793	1.793
2	120	118.131	1.869	1.558
3	140	137.012	2.988	2.134
4	160	157.765	2.235	1.397
5	180	176.318	3.682	2.046
6	200	198.612	1.388	0.694
7	220	218.924	1.076	0.489
8	240	238.234	1.766	0.736
9	260	260.168	0.168	0.065
10	280	281.435	1.435	0.513
11	300	301.231	1.231	0.410
Average				0.570

$$\delta = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}} \quad (6)$$

$$UA_1 = \frac{\delta}{\sqrt{n}} \quad (7)$$

So, we find:

$$\bar{x} = 103.33$$

$$\delta = 1.29$$

$$UA_1 = 0.33$$

TABLE 5. Error Value

Standard Instrument (calibrator)	Sensor measurement results MQ-135
(100 ± 2) ppm	(103.3 ± 0.333) ppm
Error = 3.3%	

MQ-135 sensor testing analysis

Analysis of the sensitivity characteristics of the MQ-135 sensor, the test results with the sensitivity characteristics of the sensor datasheet is as follows:

- Based on the test, the sensor resistance value (R_s) is obtained when the CO gas concentration of 100 ppm is 19.114 k Ω , which means that the sensor resistance value (R_s) has been valued in the range of 6-20 k Ω .
- Based on the test results obtained sensor resistance value (RS) when the CO gas concentration of 300 ppm is 9.492 k Ω .

So that, concentration slope rate obtained:

- Concentration slope rate: $R_s(300 \text{ ppm}) / R_s(100 \text{ ppm}) < 0.5$
- Concentration slope rate: $R_s(9.492 \text{ k}\Omega) / R_s(19.114 \text{ k}\Omega) < 0.5$
- Concentration slope rate: $0.497 < 0.5$

TABLE 6. Results of analysis of MQ-135 sensor characteristics

Parameter	Technical Parameters	The Result	Information
Rs 100 ppm CO	6 – 20 K ω	19.114 k Ω	Matching
(300 ppm / 100 ppm) CO	< 0.5	0.492	Matching

From the results of the analysis of the sensitivity characteristics of the sensor shows that the MQ-135 sensor has excellent sensitivity. The tool can detect or measure the concentration of carbon monoxide (CO) gas contained in the air in units of ppm (parts per million). The calibration tool at the measurement at 100 ppm with the measurement results of the standard measuring instrument is (100 ± 2) ppm, and the measurement results of the MQ-135 sensor is (103.3 ± 0.333) ppm, with an error value of 3.3%.

CONCLUSION

The CO gas monitoring measuring device with dimensions of 11 cm \times 8.6 cm \times 2.9 cm using MQ-135 sensor and Arduino Uno microcontroller to display temperature and humidity on a 4.2 inch LCD. Krisbow KD09-224 Carbon Monoxide Meter is a comparison tool calibrator, against our monitoring gauges. Testing by experimenting as much as 15 times, to determine the value of the measurement uncertainty. Based on the results of the data when testing, the average amount of measurement, \bar{X} is 103.33, with a standard deviation, $\delta = 1.29$, and the uncertainty value of the measurement results, UA_1 , is 0.33%.

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