REAL TIME FACTORY SMOKES MONITORING SYSTEM USING ANDROID SMARTPHONE

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Abstract - Owing to widespread deforestation and the rapid growth of modern plants, we can see and experience a lot of air that is no longer what it once was. Carbon Monoxide (CO), which is generated by residual combustion in industrial plants and emitted through factory chimneys, is one of the factors that contribute to air pollution. This study was designed to help the government monitor Carbon Monoxide (CO) levels more efficiently because it can be done at any time in real time using an Android smartphone's media. Furthermore, this research is being conducted to develop simple technology that can be used by parties who need or have an interest in monitoring Carbon Monoxide (CO) levels as well as reducing the number of emissions in the local area. The results showed that the MQ-7 sensor on the monitoring tool could detect carbon monoxide levels accurately and had a 0.72 percent error rate when retrieving data several times. The CO meter's sensitivity is equivalent to that of an NDIR (Non-Dispersive Infrared Detector) Analyzer, which is commonly used for measuring and detecting carbon monoxide levels in the air. These findings suggest that this instrument can be used to better monitor carbon monoxide (CO) levels in the air.

Keywords: CO Monitoring, Sensor MQ-7, Bluetooth HC-06, Arduino UNO, MIT App Inventor.

I. INTRODUCTION

Humans need clean air as one of their most basic needs. We can't survive without air. Here, the air is Oxygen (O2). We can breathe and survive because of this air. There are many instances today where we can see and feel air that is not as clean as it once was due to rampant deforestation and the rapid development of industrial factories [1]. The air is now polluted. As a result, our breathing can become more difficult. Carbon Monoxide (CO), which comes from the combustion residue from power plants and is released via the industrial plant chimneys, is one of those factors that contribute to air pollution.

The government has conducted monitoring on each industrial plant using the NDIR Analyzer however, it is deemed inefficient to prevent the occurrence of air pollution and knowing the levels Carbon Monoxide (CO) that the factory produces every day [2]. Besides that, not all factories are in Indonesia has a monitoring tool so that the carbon content Monoxide (CO) produced from combustion remains the factory still exceeds the set standards by the government which results in air pollution.

From the various problems that exist, it is made innovation prototype carbon content monitoring system Monoxide (CO) with Bluetooth communication for assisting the government in monitoring levels to be more efficient because it can be done every time in real time using Smartphone media Android that has installed a monitoring application previous [3]. This monitoring system uses sensors MQ-7 gas which is used as a detector for Carbon gas Monoxide (CO)[4]. The sensor can detect levels 10 ppm - 10000 ppm. PPM (Part Per Million) is unit of concentration in CO gas that can be measured by gas sensor MQ-7. The output from the MQ-7 sensor is a signal analog which is then converted into digital signals by using the Arduino UNO microcontroller. Later the output value will be displayed on application installed on the Android Smartphone created using MIT App Inventor.

II. METHOD

The design stages of this research were carried out in a gradually. Before doing this research, especially previously reviewed some of the research that is still related. As literature, researchers study manuals and journals about the MQ-7 sensor and a carbon monoxide monitoring system. Collection materials and requirements for a level monitoring system carbon monoxide (CO) consists of three parts between the others hardware (hardware), software (software) and supporting devices. Hardware (hardware) consists of Arduino UNO, MQ-7 sensor, and modules Bluetooth HC-06. Whereas in the software, namely Arduino IDE software and MIT Android Inventor. For supporting device needed a small pipe functioned as a chimney as well as an acrylic board used as a box to place monitoring tools [5].

Design of a carbon monoxide monitoring system (CO) with wireless communication (Bluetooth) using the Arduino Microcontroller shown in Figure 1. Real-time Factory Smokes Monitoring System Using Android Smartphone.

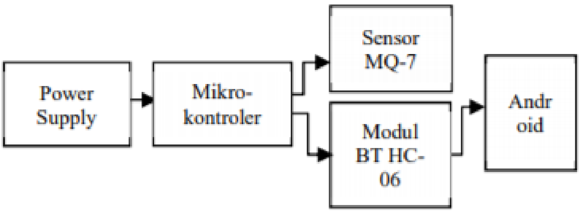

Figure 1. CO Level Monitoring System Design Model

The design of this CO level monitoring system will make an acrylic box that will hold several tools electronics used in monitoring CO levels. in the box there is a series of monitoring tools including the Arduino UNO microcontroller, the MQ-7 sensor and Bluetooth Module HC-06. For prototype design shown in Figure 2.

Figure 3 is a schematic diagram of the entire hardware circuit for a monitoring system for carbon monoxide (CO) levels in industrial chimneys with wireless communication via an Android smartphone.

The design software (software) in question is a program that is inserted into the Arduino microcontroller. The choice of Arduino language was chosen because it is sufficient for mathematical calculations in the CO gas level monitoring system and is open source. Because of its open-source nature, many libraries have been developed by individuals or communities outside the Arduino developer itself[6].

An overview of the course of the first program is to create a program to detect the voltage from the AC 220 V source entering the power supply. If the power supply gets power from an AC 220 V source, the microcontroller will read the voltage sent by the power supply. Then proceed with reading the program to be able to convert the voltage read by the MQ-7 sensor in the form of an ADC so that it can be displayed on an Android smartphone via the HC-06 Bluetooth module.

The next step is to create an Android application program that will be installed on a smartphone so that it can connect the HC-06 Bluetooth module to Android so that data from the sensor can be displayed. During the connection process between the Bluetooth module and Android, the pairing process is carried out so that the devices can connect to each other. In addition, making an application program functions to be able to display data from the MQ-7 sensor which is then displayed on an android application that has been installed on a smartphone so that it can monitor CO gas levels in the surrounding environment. The software used in this section is the online-based MIT App Inventor, where to run the application, it must be connected to an internet network.

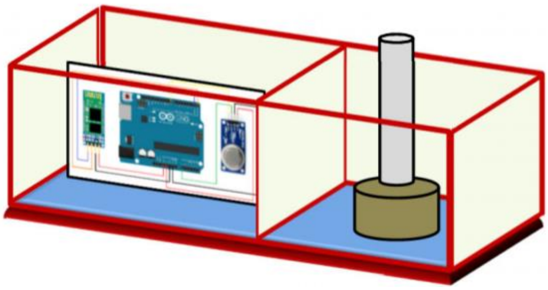

Figure 2. Prototype Design

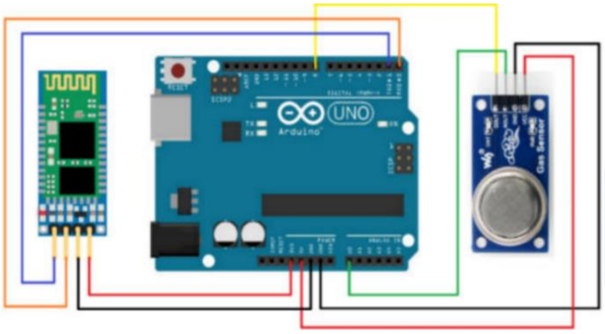

Figure 3. A Schematic Diagram

III. RESULTS AND DISCUSSION

After going through several stages of the research design, to find out whether the monitoring results obtained from the carbon monoxide (CO) level monitoring system are in accordance with the CO meter value and are well calibrated, data analysis is carried out. The analysis that will be discussed is how to calibrate the MQ-7 Carbon Monoxide (CO) gas sensor in order to measure the gas concentration in units of ppm (parts per million). The following is a graph of the characteristics of the MQ-7 sensor in Figure 4.

When viewed from the graph above, it can be seen that the ratio MQ-7 gas sensor resistance (Rs / Ro) will be a value = 1 at when the gas concentration of CO = 100 ppm. The meaning is on when the gas concentration of CO = 100 ppm, the value of Rs = Ro because Rs / Ro is 1. This can be proven by the following equation:

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

Where $\frac{R_s}{R_o}$ is sensor resistance ratio, R_s is sensor resistance at different gas concentrations (kΩ), and R_o is sensor resistance at 100 ppm CO gas concentration (kΩ).

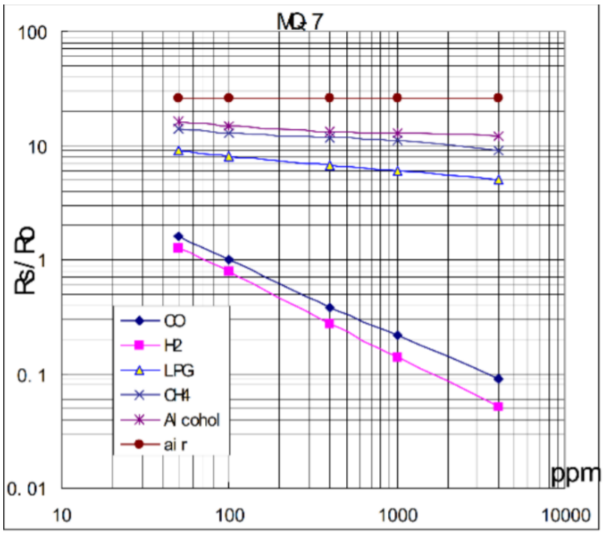

Figure 4. Graph Of MQ-7 Sensitivity Characteristics

Through the formula above, you will get the value of Ro, because the Ro value is not explained on the sensor datasheet MQ-7. In addition, a gas concentration measurement tool is also needed Carbon Monoxide (CO Meter) which functions as a calibrator.

$$V_{out} = \left(\frac{R_l}{R_s} + R_l\right) \times V_{cc} \qquad (2)$$

Where R_l is sensor load resistance, V_{out} is sensor output voltage (Volt), and V_{cc} is supply voltage sensor (Volt).

Basically, the value of the concentration of Carbon gas Monoxide (CO) in ppm can be determined by taking some R_s (resistance sensor MQ-7 at the gas concentration level different) and then look for the mathematical model (equation of lines) for each change in concentration CO gas. The reading value of R_s is read by the microcontroller in the form of ADC then processed to obtain the values of V_{out}, R_s and $\frac{R_s}{R_o}$ using equation (1).

The circuit implementation is shown in figure 5. The main component is a 12V power supply (Power Supply), Microcontroller, MQ-7 Gas Sensor, Module Bluetooth HC-06. As for making Android applications use the MIT App Inventor application where the process manufacture must be connected to an internet connection because to run the MIT App Inventor application must go through the official website. Below is a display application that have been installed on the Smartphone Android that was successfully made for the monitoring system Carbon Monoxide (CO) levels are shown in Figure 6.

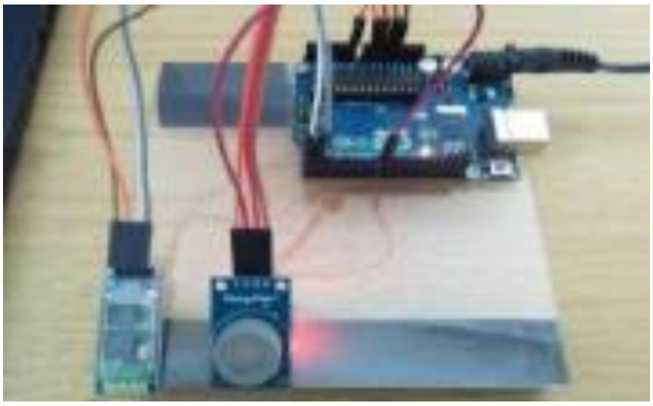

Figure 5. The Results of Monitoring System Design Carbon Monoxide Levels

Figure 6. Display the Monitoring Application on Android smartphone

In testing carbon content monitoring tools Monoxide (CO) consists of several blocks, between another power supply block (Power Supply), block microcontroller, MQ-7 gas sensor block, module block Bluetooth HC-06, and block Android apps. Following that, a description of each test block is given.

1. Power Supply

The Power Supply in this system has an important role, namely as a source of DC voltage. Based on the measuring instrument, the power supply output is equal to 12.22 Volts DC. In a series of Carbon monitoring systems Monoxide (CO), which requires an intermediate power supply input another Arduino microcontroller circuit, the HC-06 sensor, and the HC-06 Bluetooth module. For more details, you can see in table 1.

2. Microcontroller

In microcontroller testing carried out with connect the MQ-7 sensor and display the value which is issued by the sensor via the serial monitor Arduino. The serial monitor on this Arduino can displays the required result value from reading sensor MQ-7 which is then processed to obtain formula used to produce CO levels in ppm units. The following shows the value in Arduino is shown in Figure 7.

Table 1. Power Supply Measurement Results

No	Device Being Measured	Result Measurement
1	Power Supply Output	12,22 V
2	Input Microcontroller	12,15 V
3	Input Sensor MQ-7	4.13 V
4	Input Modul Bluetooth HC06	3,26 V

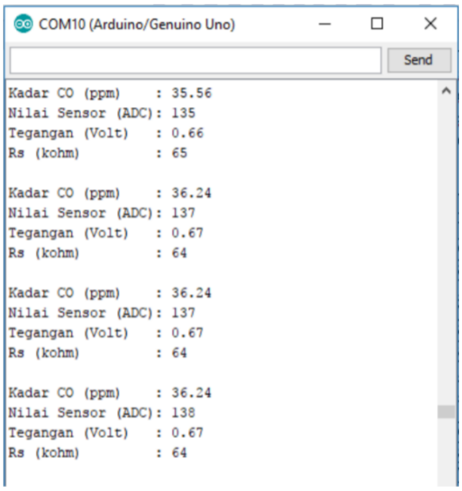

Figure 7. Display of values generated by the MQ-7 sensor on the Arduino Serial Monitor

3. Gas Sensor MQ-7

Testing of the MQ-7 gas sensor block is carried out in two stages. The first stage is testing with the calibration method. At this sensor calibration stage, it is carried out by comparing the output of the reading of CO levels produced by motorcycle exhaust fumes which have been converted into PPM units with the output of the gas concentration produced by a standard measuring instrument, namely the CO Meter. Here is a picture of the CO Meter in Figure 8.

Figure 8. CO Meter

Table 2. Sensor Test Results with A Calibrator Tool CO Meter

Minute	CO Meter (ppm)	Sensor MQ-7 (ppm)	Error (%)
1	35	34.68	0.91
2	35	35.04	0.11
3	34	33.59	1.20
4	34	34.32	0.94
5	25	25.39	1.56
6	26	26.04	0.15
7	36	35.92	0.22
8	33	32.88	0.36
9	37	36.89	0.29
10	26	26.37	1.42
Average Error		0.72	

Table 3. MQ-7 Gas Sensor Sampling Test Results

Condition	PPM Value	ADC	V_{out}	R_s (kΩ)	$\frac{R_s}{R_o}$
Motorcycle start switched on	31.81	126	0.62	71.19	2.52
Motorcycle gassed slowly	52.22	178	0.87	47.47	1.68
Motorcycle gassed quickly	83.17	241	1.18	32.45	1.15
Motorcycle start-stop	65.55	207	1.01	39.42	1.39

Table 4. CO Meter Test Results with the MQ-7 Sensor

No	PPM Value	ADC	V_{out}	R_s (kΩ)	$\frac{R_s}{R_o}$
1	20	91	0.44	102.42	3.63
2	50	173	0.84	49.52	1.75
3	100	269	1.31	28.16	1
4	150	348	1.70	19.41	0.68
5	200	398	1.97	15.77	0.56

For the second test, testing was carried out monitoring by sampling method. This test conducted to determine the value of carbon content Monoxide (CO) in vehicle smoke conditions vary to ensure that monitoring tools working properly. The following is Table 3 results sampling testing. The formula used to find the value of Rs is in accordance with equation 2.

The table shows the value of carbon gas levels Monoxide generated by motorbikes is appropriate with different conditions. For test results can be seen in Table 4. In the table above it can be seen that the value of Rs at the tim Carbon Monoxide (CO) gas concentration of 100 ppm is equal to 28.16 kΩ. This is what becomes the benchmark for calibration process. Furthermore, the relationship between ppm Carbon Monoxide (CO) and Rs / Ro is poured in graph form and then look for the equation, below is a graph of the sensitivity characteristics of the MQ-7 sensor in Figure 9.

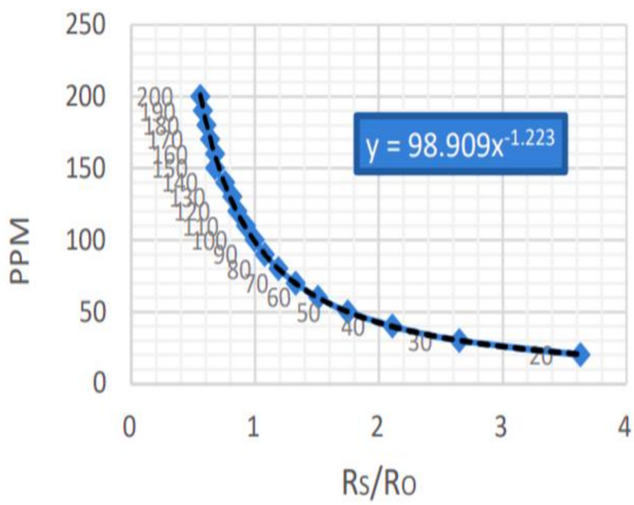

Figure 9. Graph of MQ-7 Sensor Sensitivity Characteristics

Table 5. Data Transfer Test Results

Data sent (on the Arduino serial monitor)	Data received (On Android application)
36.19	36.19
36.78	36.78
35.92	35.92
35.28	35.28
35.38	35.38
34.22	34.22
34.10	34.10

Figure 9 shows that there is a relationship between the PPM value on the CO Meter and the MQ-7 sensor resistance value as shown in Table 4.4. By using trendline power regression, the equation ($y = 98.909x^{-1.223}$) is obtained which is the relationship between ppm CO and Rs / Ro and can be used as a formula to find the value of CO gas levels (ppm) on the Arduino microcontroller.

4. Modul Bluetooth HC-06

The HC-06 Bluetooth module is a communication media device used between the Arduino UNO and the application on an Android Smartphone. The data sent is the value of Carbon Monoxide (CO) levels in the air with units of parts per million (ppm) which have been previously processed by the Arduino Microcontroller. The results of data transfer testing can by seen in Table 5.

5. Android Application

The Android application here acts as a medium monitoring of Carbon Monoxide in the air where the value of CO levels will be displayed when running this application. Before running the application, you are required to turn on Bluetooth connection as well as pairing between Android smartphone with monitoring tools such as ones previously described. After the application is open next is to connect the Bluetooth connection by touching the Select Bluetooth button located on screen and will enter Bluetooth selection mode previously installed on an Android Smartphone. Select HC-06 and process Carbon level monitoring Monoxide can be done. Value of Carbon content Monoxide will appear on the screen and will change the value corresponds to the detected Carbon Monoxide level is in the air. The following is a display image of the application monitoring in Figure 10.

Figure 10. Monitoring Application Display

Testing communication media on monitoring tools Carbon Monoxide (CO) levels are measured based on the maximum distance that can be reached by that device already installed the HC-06 Bluetooth module with Android smartphone. This is done to find out the maximum Bluetooth connection capability range for can perform data transmission. Apart from that this testing also includes testing the pairing distance (installation) between device, because the pairing process is very necessary in order the connection of the Bluetooth module connection to the Smartphone.

Table 6. Results of connection testing based on distance

Distance (m	Data Sent (ppm)	Data Received (ppm)	Time respons (s)	Status
1	34.26	34.26	1	Connected
5	34.26	34.26	1	Connected
10	33.22	33.22	1	Connected
15	33.22	33.22	1	Connected
20	33.22	33.22	1	Connected
25	33.22	33.22	1	Connected
30	33.22	33.22	1	Disconnected

Based on the data obtained are the maximum distance Bluetooth can pair the Android Smartphone is 29 meters away. Furthermore, after the pairing and pairing processes are successful then testing the Bluetooth range with an Android Smartphone. The following is the data the maximum range distance measurement results as well Bluetooth delivery as outlined in the form of a table as in Table 6.

IV. CONCLUSION

According to the findings, the MQ-7 sensor on the monitoring tool can detect carbon monoxide levels accurately and has an error rate of 0.72 percent when conducting multiple data retrievals for calibration needs using a CO meter as a reference. Given the CO Meter's accuracy, which is comparable to that of the NDIR (Non-Dispersive Infrared Detector) Analyzer, which is commonly used. When sending the result of sensor data monitoring from the unit to an Android Smartphone through Bluetooth communication, testing revealed that the maximum distance that can be achieved for the connecting and pairing phase is 29 meters. Furthermore, the maximum distance that can be reached / linked for the monitoring phase is 29 meters. However, at 30 meters, the Bluetooth link is lost and cannot be reconnected with monitoring tools, and Android Smartphones are unable to receive data sent by the monitoring tool.

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