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CARBON MONOXIDE MEASURING SYSTEM USING MQ-7 SENSOR WITH CLOUD STORAGE

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ABSTRACT

Carbon monoxide (CO) gas cannot be detected by sight or smell but is highly detectable and is formed from incomplete combustion such as in motor vehicles. Currently monitoring CO gas levels and measurement data at any time cannot be accessed all the time. Therefore, a measuring instrument system with data storage is required. We developed an instrument to measure CO gas levels in the air. The system developed uses the MQ-7 and ESP8266 sensors to produce a CO gas level measurement device with Cloud Storage. This research is a type of engineering research. The measurement technique used is a direct and indirect measurement. The direct measurement technique is done by comparing CO level data from standard tools with measuring instruments. Indirect measurement techniques are carried out by analyzing the data. Based on the research objectives, the specifications of the work tools are the average accuracy percentage of 97.27%, and the precision of 97.31%. Based on these result, the CO gas level measuring tool has a measurement accuracy and precision of close to 100%. So it is concluded that the CO level measuring tool can work properly.

Keywords : Carbon Monoxide; MQ-7; Cloud Storage

I. INTRODUCTION

According to the Air Quality of Life Index (AQLI), the average life expectancy of Indonesians could lose 1.2 years at current pollution levels as air quality fails to meet World Health Organization (WHO) requirements for concentrations of delicate particulate matter [1]. Air is one of the crucial parameters in the life of living things. Air quality is a parameter that needs attention to maintain health and the environment [2]. The growth of industry and the development of motorized vehicles at this time impacted air pollution and decreased air quality. The gases produced from incomplete combustion will form compounds such as CO gas, which can affect the respiratory tract. [3].

CO gas is an invisible killer. CO gas cannot be detected by sight or smell but is highly toxic. With advances in technology as it is currently impacting in a more advanced direction. Air quality monitoring, namely CO gas levels in the air, by building hardware that is connected to an air quality monitoring system [4]. To measure CO levels, a Gas Analyzer is used with units of percent volume. The unit of CO concentration in the air is ppm or parts per million [5].

Most of the CO gas is formed from the combustion of fossil fuels in the air, in the form of exhaust gases [6]. CO gas has a lifetime of about a month in the atmosphere [7]. According to the Regulation of the Minister of Manpower and Transmigration of the Republic of Indonesia No. 13 of 2011 the threshold value for CO levels is 25 ppm [8]. According to The U.S. National Ambient Air Quality Standards (NAAQS) limits the levels of CO gas in the outside air are 9 ppm for 8 hours and 35 ppm for 1 hour. Based on a the Health and Safety Executive presentation that CO gas concentrations above 30 ppm can lead to high COHb concentrations and adversely affect workplace health [9].

One of the tools used in measuring CO gas levels is a CO meter. The CO meter measuring CO gas can be used for air quality parameters, and the CO meter has a sensor that produces a reading of the CO gas level value.

Based on that reference, a digital measuring instrument based on the Internet of Things was developed so that measurements can be carried out effectively and efficiently and save time, and measurement data can be accessed anywhere.

In research [3], [10], [11] dan [12] built a CO gas level measuring device that uses a microcontroller with an MQ-7 sensor as the main sensor. The measurement results of CO gas levels in this tool are displayed using an LCD which is not possible to monitor every time. Taking measurement data is done manually and data storage uses micro SD.

In research [13], a monitoring tool for CO gas levels was built using a microcontroller with an MQ-9 sensor as the main sensor. This tool detects CO gas levels and then will be displayed via LCD. This tool only monitors CO gas levels and the measurement data is not stored.

In research [14], a prototype design for detecting CO gas levels using a microcontroller with an MQ-7 sensor as the main sensor was built. The measurement results of this tool are displayed through laptop media so it is difficult to carry everywhere. The distance of sending measurement data from the sensor to the display media is very limited because it uses radio telemetry as a measurement data sender.

In research [15], a monitoring tool for CO gas levels in industrial chimneys was built using a microcontroller with an MQ-7 sensor as a sensor. This tool measures CO gas levels and then displays them through an Android smartphone. This tool has a weakness where the distance between the tool and the android smartphone is very limited. This tool uses bluetooth as a sender of CO gas level data to an android smartphone.

In research [16] built a gas emission detection tool for vehicles using microcontrollers and gas detection sensors. This tool detects gas emissions then displays on the LCD on the tool and on the android smartphone via bluetooth. This tool has the disadvantage that the distance between the tool and the smartphone is limited because sending sensor data using bluetooth.

Based on previous research for measuring CO gas levels, a CO gas level meter was developed that has Cloud Storage by utilizing the Internet of Things. In this study using NodeMCU ESP8266 microcontroller and MQ-7 sensor. The measurement results will be stored in the database and then displayed via a smartphone display.

II. METHOD

This research was conducted using engineering methods. In engineering research, the discussion of design activities involves relatively new things. The steps in conducting engineering research are describing the tools that are made to meet the specified specifications, designing the modeling of the tools created and testing the tools. The final results of engineering research are used for improvements in testing methods and procedures and improvements in the design activity itself [17]. The main steps in engineering research are shown in Figure 1.

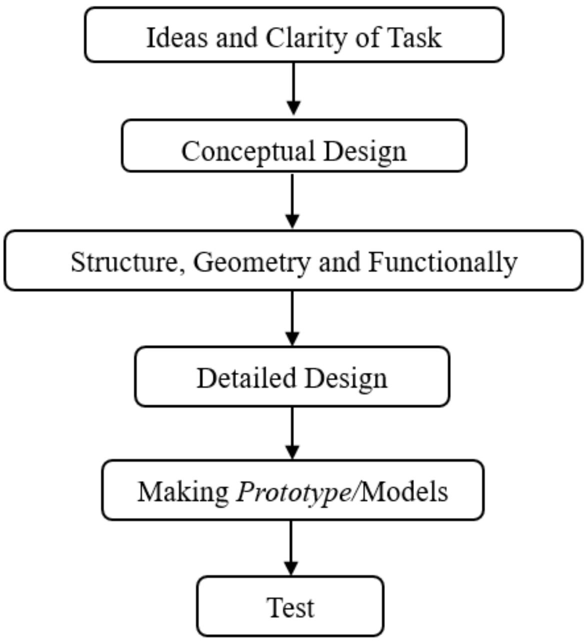


Fig. 1. Engineering research stages

Figure 1 was the engineering research stages. The research phase begins with determining ideas and clarity of tasks such as searching for literature studies from various sources. The conceptual design stage is the stage of realizing the idea before forming the system. The components of the system to be formed are arranged geometrically according to their respective functions. The block diagram of the tool system design can be seen in Figure 2.

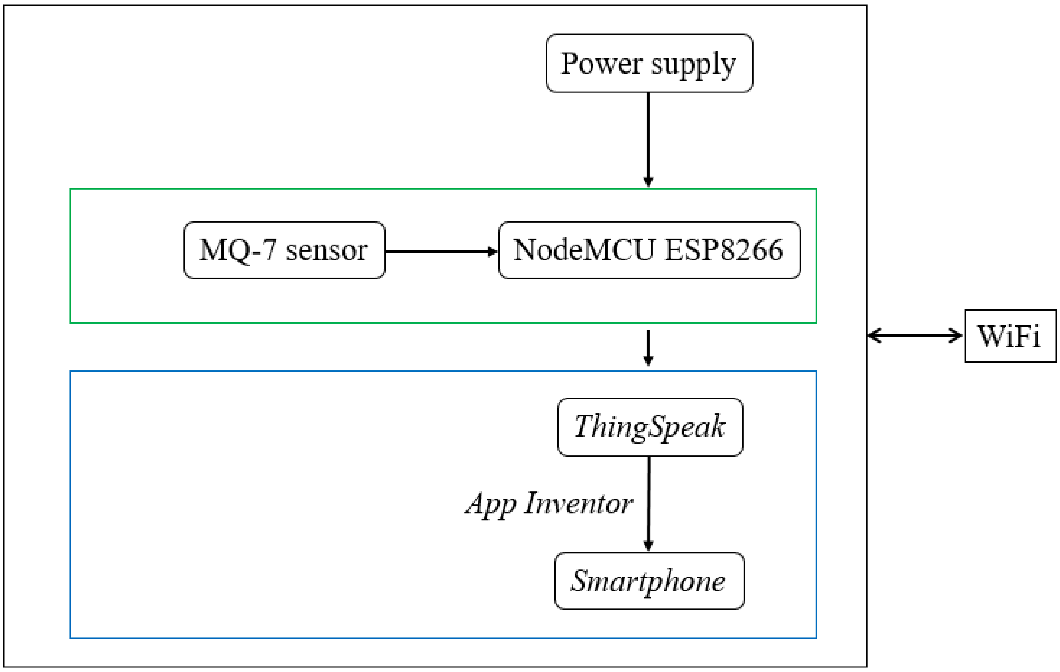


Fig. 2. Block diagram of the tool system design

Figure 2 is a block diagram of the system design with the MQ-7 as the CO gas sensor. The sensor is connected to the ESP8266 microcontroller, and the power supply is used as a voltage source. ESP8266 sends the measurement results of CO gas levels to ThingSpeak when connected to the internet according to the program that has been made. The measurement results can be displayed through the smartphone display with an application designed using the App Inventor. The detail design stage consists of software design and hardware design. The software design consists of the microcontroller software design and the App Inventor software design. The microcontroller software design can be seen in Figure 3.

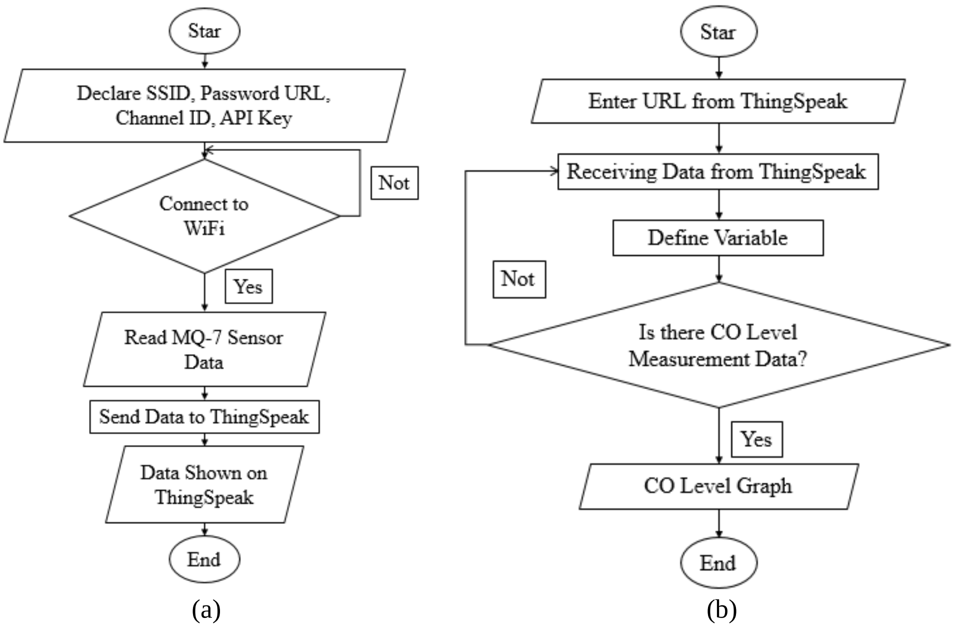


Fig. 3. (a) Flowchart of microcontroller software design and (b) Flowchart of App Inventor design

Figure 3a is a microcontroller software design flowchart that starts by connecting the NodeMCU ESP8266 connected to a WIFI transmitter. Sensor data will be read when NodeMCU is connected to an internet connection, and data will be sent to ThingSpeak. Figure 3b is the application design flow in the App Inventor. The stage begins by entering the URL from ThingSpeak. Then the App Inventor will define the data in ThingSpeak. The measurement data in the form of CO gas levels will be displayed on the smartphone in the form of numbers and graphs. After the software design is continued with the hardware design, which consists of several electronic components. The device hardware design can be seen in Figure 4.

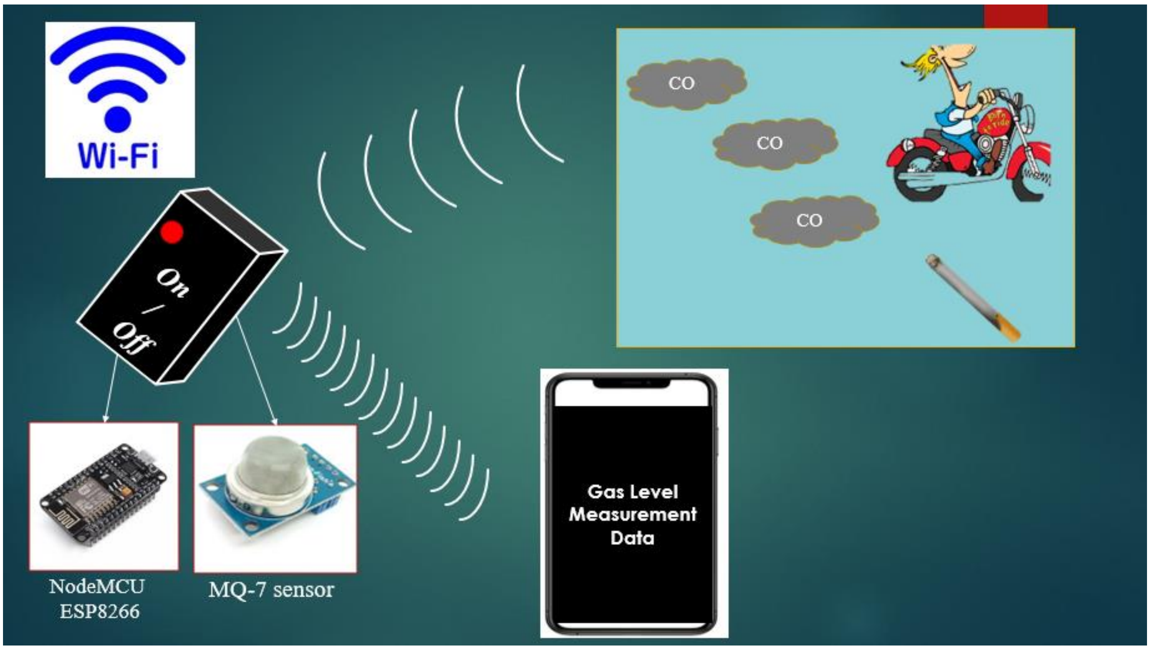


Fig. 4. Device hardware design

Figure 4 is a hardware design consisting of electronic components. The hardware is in the form of a box, which consists of a power supply as a voltage source, Sensor MQ-7 as a CO gas sensor, and NodeMCU as a microcontroller. The IoT system on the measuring instrument uses WIFI as a sender of data from the device to the ThingSpeak website and will later be displayed on the smartphone.

The next stage is the prototype stage. The stage of making a CO gas level measuring instrument is made according to the design that has been made. The system that has been completed will be tested for the tool. The last stage is the testing stage of the instrument. Tests are carried out to ensure whether all systems are functioning correctly and look for if there are errors in the system.

III. RESULTS AND DISCUSSION

The result of this study were consistent with the stated objectives and performance specifications from the design of a CO gas level measuring device using the MQ-7 sensor with Cloud Storage. The specific design consist of a series of measuring instruments can be seen in Figure 5.

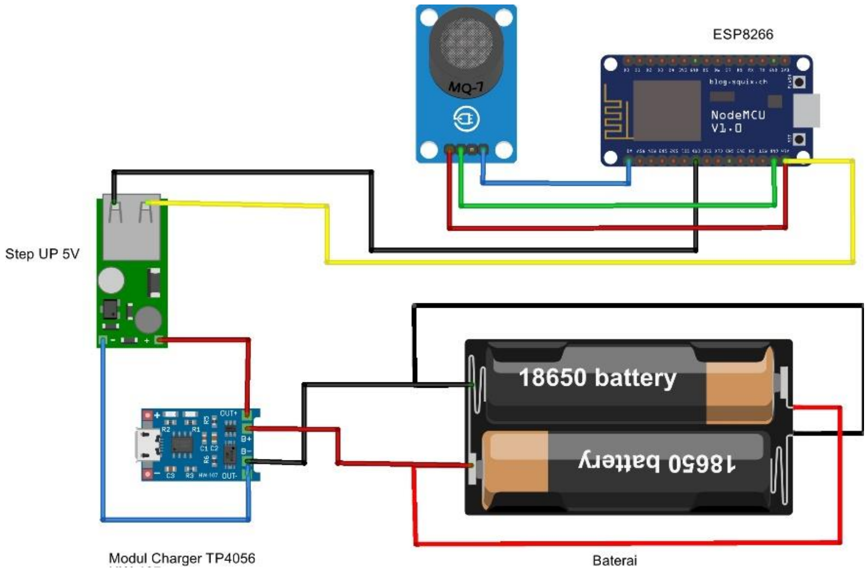
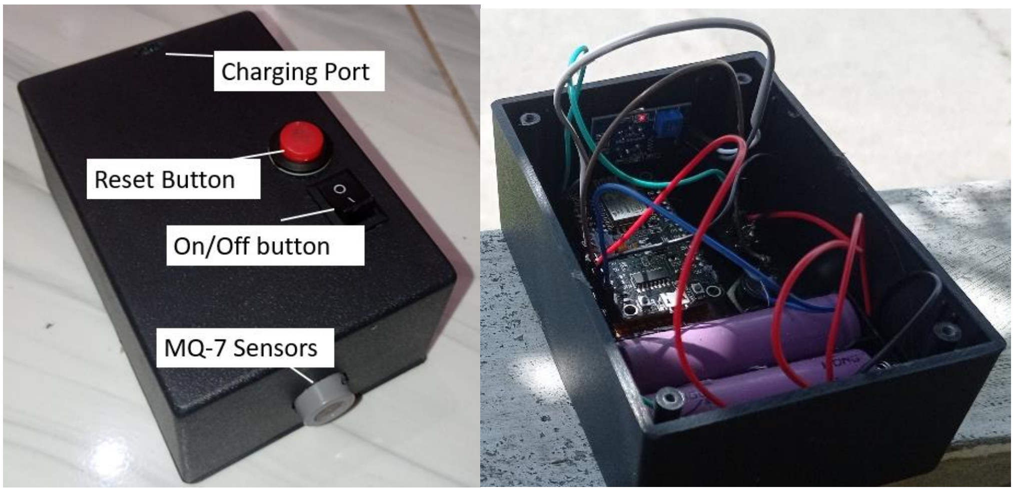


Fig. 5. Series of CO level measuring instruments

In Figure 5, the series of CO levels can function after the MQ-7 sensor circuit is connected to the power supply circuit. The MQ-7 sensor has 4 pins, first Vcc as a positive voltage source of +5V, second Ground, third D0 as Digital output, and A0 as Analog output. Vcc is connected to a voltage source, pin A0 is connected to A0 on the ESP8266 and the ground pin is connected to ground on the ESP8266. The MQ-7 sensor is a CO gas detection sensor that works at a voltage of 5V [11]. The Charger module B+ is connected to the battery positive, and B- is connected to the battery negative with the battery in parallel. The Charger Out+ module is connected to the In+ Step Up, and the OUT- is connected to the IN- Step Up. Step Up functions to increase the voltage [18]. The Step Up output voltage is 5V, then connected to the ESP8266. The microcontroller is an electronic component that can be programmed and can execute programmed steps [19]. The ESP8266 has pins that can be connected to other components, and the ESP8266 works at a voltage of 2.5V-3.6V [20]. The series of measuring tools for CO levels are set in the toolbox as shown in Figure 6.



(a) (b)

Fig. 6. (a) The outside view of the measuring instrument and (b) The inside view of the measuring instrument

In Figure 6, the measuring instrument box contains a series of CO level measuring instruments, on/off buttons, and reset buttons. To turn the measuring instrument on and off, the on/off switch is used. The reset button returns the measuring instrument to its original state. By using the charger module, in addition to charging the battery, it can also turn on the measuring instrument. The tool will measure the CO gas level then the measurement results will be sent to ThingSpeak when connected to the internet according to what has been programmed in the Arduino IDE. Arduino IDE is a piece of software that allows programming the Arduino language in C. The IDE allows you to write a program step by step and then upload the instructions to the NodeMCU ESP8266 board [21]. ThingSpeak display in the form of a graph can be seen in Figure 7.

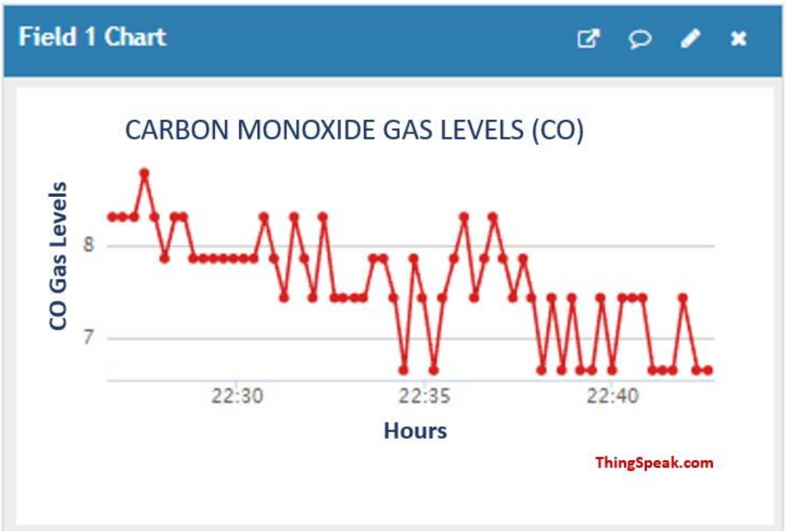


Fig. 7. Thingspeak data display

ThingSpeak is storing and retrieving data through a Local Area Network [22]. ThingSpeak collects the data generated by sensors or actuators, analyzes and displays the data [23]. Displays the output of the perceived data in the form of a graph at the web level. ThingSpeak communicates with the help of an internet connection which acts as a carrier 'data packet' between the connected 'things' and the cloud [24]. To access ThingSpeak, create an account, create a channel, and set the display on ThingSpeak. When the CO measuring instrument works, the measurement data will be sent to ThingSpeak via an internet connection. The data will be displayed in the form of a graph. The measurement result data can be displayed on the Android smartphone. The application designed in the Inventor app can be seen in Figure 8.

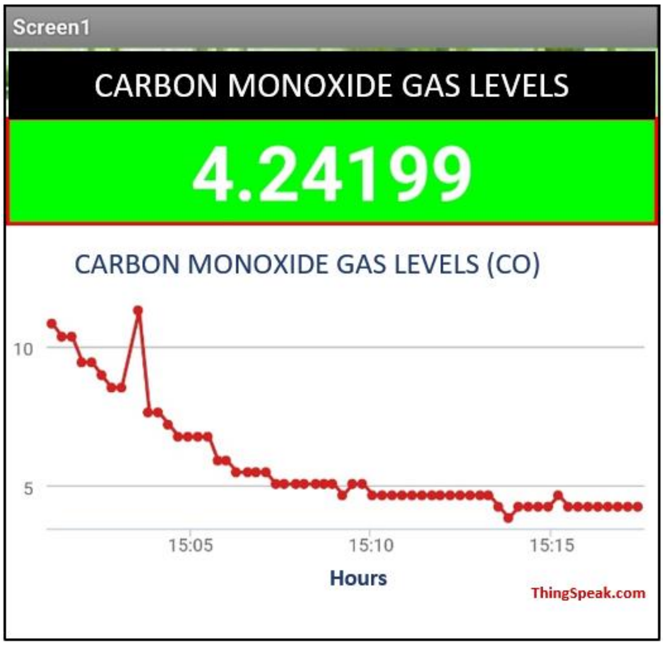


Fig. 8. Data display on android smartphone

App Inventor is an open source web that has a tool for creating Android applications based on visual block programming [25]. Apps designed through App Inventor are linked to ThingSpeak. The measurement results data on the smartphone are displayed as numbers and graphs. Furthermore, the performance specification of the CO level measuring instrument uses the MQ-7 sensor. The characteristics of the MQ-7 sensor are obtained by knowing the relationship between the sensor output voltage value and ppm and a regression curve is made, as shown in Figure 9.

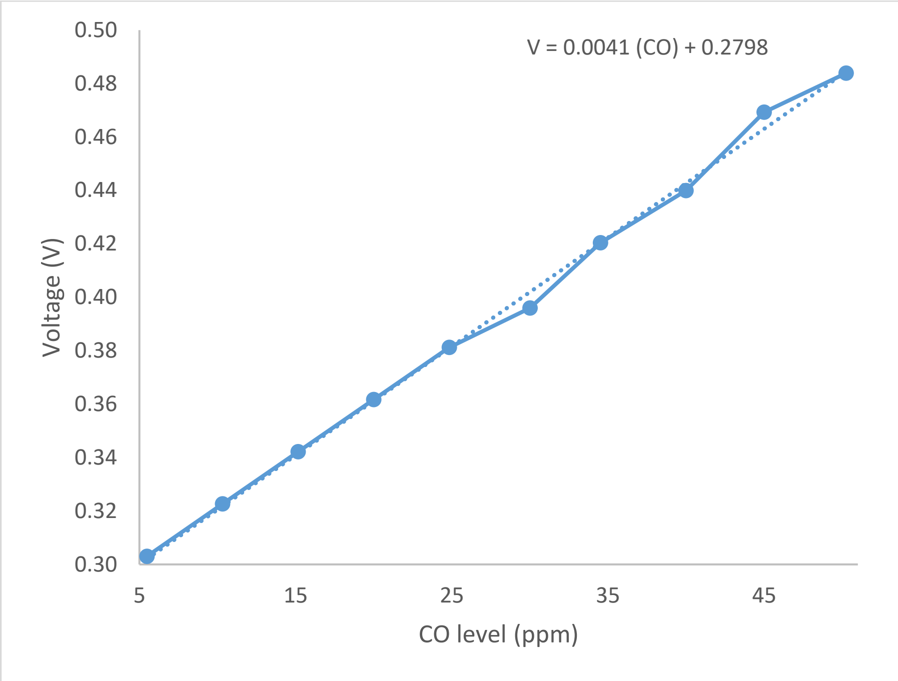


Fig. 9. Relationship between sensor output value and ppm

The formula obtained is used to convert the data from the sensor output value into the form of ppm. Where x is ppm and y is sensor output value. The equations obtained are:

$$V = 0.0041\,(CO) + 0.2798 \quad (1)$$

Accuracy data were obtained by comparing CO levels with standard tools to measure CO levels using the MQ-7 Sensor. The closer the CO levels to the CO level measuring instrument using the MQ-7 Sensor with standard tools, the more accurate the tool is declared. Table 1 is data on the accuracy of CO levels using the MQ-7 Sensor.

Table 1. CO Level Accuracy Data Using the MQ-7 Sensor

Data	Standard Tools	Measuring Tool	%Error	%Accuracy
1	15	15.22	1.47	98.53
2	28	26.3	6.07	93.93
3	29	27.51	5.14	94.86
4	30	28.12	6.27	93.73
5	35	34.47	1.51	98.49
6	39	37.83	3.00	97.00
7	52	51.67	0.63	99.37
8	56	56.41	0.73	99.27
9	62	63.02	1.65	98.35
10	71	71.6	0.85	99.15
Average			2.73	97.27

In Table 1, it can be seen that the CO levels obtained on standard equipment are not much different from the frequency with CO measuring instruments using the MQ-7 sensor. Data on the precision of measuring CO levels using the MQ-7 sensor is obtained by taking CO levels in the same position repeatedly ten times. Table 2 is data on the precision of measuring CO levels using the MQ-7 sensor.

Table 2. Data on the Precision of CO Level Measuring Instruments

Data	CO level	%Precision
1	7.19	95.52
2	7.19	95.52
3	7.19	95.52
4	6.75	98.08
5	6.75	98.08
6	6.75	98.08
7	6.75	98.08
8	6.75	98.08
9	6.75	98.08
10	6.75	98.08
Average	6.88	97.31

Table 2 shows the result of CO level precision using the MQ-7 sensor. It can be seen in the table of CO levels after taking data with the same position repeatedly with almost the same percentage of accuracy, namely 97.31%. CO level data was measured at Padang State universities and Simpang Tunggul Hitam. The instrument takes data every 15 seconds for about 1 hour. Figure 10 is the data from measuring CO levels at Simpang Tunggul Hitam (site I) and Universitas Negeri Padang (site II).

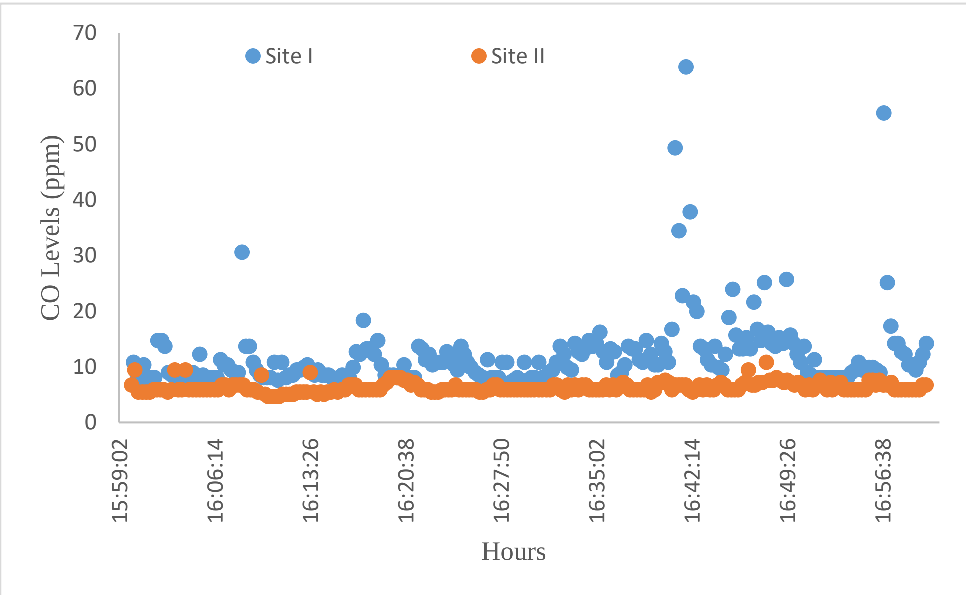


Fig. 10. Graph of CO Level measurement results at Simpang Tunggul Hitam and Padang State University

Figure 10 is a Graph of CO Level measurement results at Simpang Tunggul Hitam (site I) and Padang State University (site II). In measurements at site I, the lowest CO level was 6.75 ppm, and the highest CO level was 63.67 ppm. In the measure at site II, the lowest CO level was 4.65 ppm, and the highest CO level was 10.81 ppm. Based on The measurements in two places which can be seen in the graph, it show that the highest CO levels are at site I and the lowest CO levels are at site II. This is because site I has more vehicle activity than site site II, which affects the amount of CO level in the air. The more motorized vehicle activity, the more CO gas levels [26].

IV. CONCLUSION

Results the design of the CO gas level measuring device using the MQ-7 sensor with Cloud Storage consists of design specifications and performance specifications. The designed designs have worked well according to their respective functions. The design specification consists of the design of the tool so that it works effectively. Performance specifications consist of data analysis, namely the accuracy and precision of the tool. The accuracy of the tool is 97.27% and the precision of the tool is 97.31%. So it can be concluded that the tool works well.

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