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Design of Space-Based Carbon Dioxide Measuring Sensor Device

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ABSTRACT
This study aims to design and build a sensor device that can measure carbon dioxide (CO2) gas levels in Islamic boarding schools and universities using the MQ-135 sensor and Arduino microcontroller. The research methods used include designing hardware and software that can detect and display CO2 levels in real time. This tool is designed by utilizing the MQ-135 sensor connected to the Arduino microcontroller, equipped with an LCD screen to display the measurement results. Testing was carried out to ensure the accuracy and reliability of the tool in measuring CO2 levels. In addition, this tool is also designed to provide notification if CO2 levels exceed the specified safe limit. The results of the study showed that the designed tool successfully detected CO2 levels well and provided accurate readings. The notifications provided by the tool also functioned effectively, providing early warning to residents when CO2 levels increased. The results of the tool test showed that this sensor tool can be an effective solution for monitoring indoor air quality and helping to maintain the health of residents. Further implementation and testing in various environmental conditions are recommended to improve the performance and reliability of this tool. Thus, this sensor device can provide greater benefits in maintaining air quality and health in the household environment.
Keywords*: MQ-135 Sensor, Arduino, Carbon Dioxide Gas, Air Quality, Space*

INTRODUCTION

Carbon dioxide (CO2) is one of the types of greenhouse gases (GHG) with the highest concentration in the atmosphere. The continuous increase in CO2 emissions causes the phenomenon of global warming. Global warming has an impact on the pattern and balance of the world's climate, especially in tropical areas. The most detrimental impact is weather changes and climate shifts that disrupt the agricultural sector and food productivity.

In addition, this sensor device can also contribute to efforts to reduce overall carbon emissions. By having a better understanding of when and where CO2 emissions increase, residents can adjust their behavior patterns to reduce their contribution to the problem of climate change. By implementing this technology widely, there will be the potential to collect mass CO2 concentration data that can help researchers and governments make more effective policy decisions related to climate change mitigation.

However, in designing this sensor device, several technical challenges need to be overcome. For example, the sensor device must have high accuracy and sensitivity to detect significant changes in CO2 concentration, while remaining affordable and easily accessible to the general public, (Junaedy et al., 2022). In addition, this device must be easy to operate and can provide information that is easy for users to understand. In this context, continuous research and development is needed to create sophisticated and reliable CO2 sensor devices. Scientists, Engineers, and Innovators need to work together to overcome these technical challenges and create solutions that can have a real impact on protecting the environment and human health (Putra et al., 2020). By designing and implementing a sensor device to measure carbon dioxide gas in the household environment, we can move towards a more sustainable future, with greater awareness of the impact of human activities on climate change. Based on the problems faced, the researcher created a tool to Design and Build a Sensor Device to Measure Carbon Dioxide Gas in Households and the research will focus on a sensor device that functions to automatically detect carbon dioxide gas in households.

METHOD

This research is a type of research and development (R&D), a research design that aims to develop and validate a theory and aims to strengthen the foundations of a theory, learning and non-learning tools, and new better models. This research lasted for 10 months, from April 15, 2023, to April 7, 2024. The research stages include proposal approval, initial study, tool design and implementation, tool testing, results and discussion, and preparation of conclusions and suggestions. The tool was made at the Laboratory of the Faculty of Information Technology, Kyai Wahab Hasbullah University, Jombang. The following is a flow diagram of the value design analysis process on the running system.

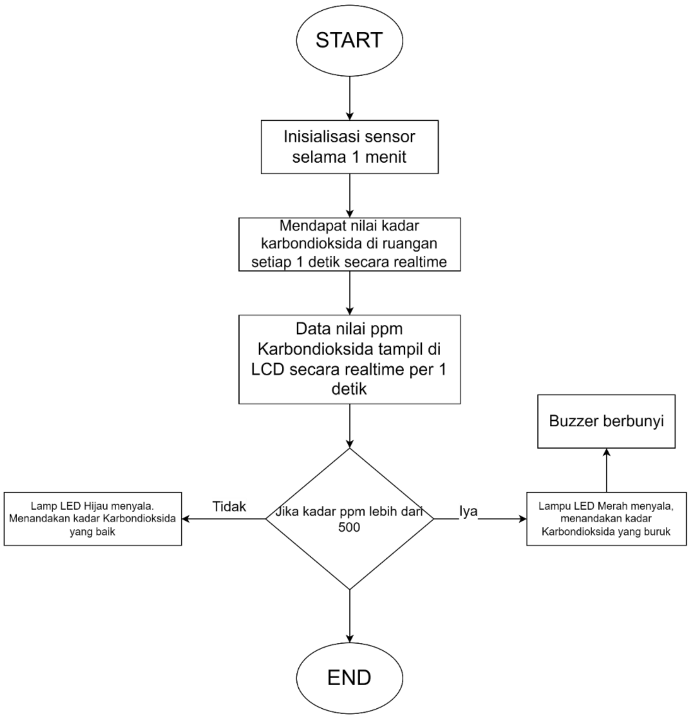

Figure 1. Research Flowchart.

Here is a block flow diagram of the air quality detection system:

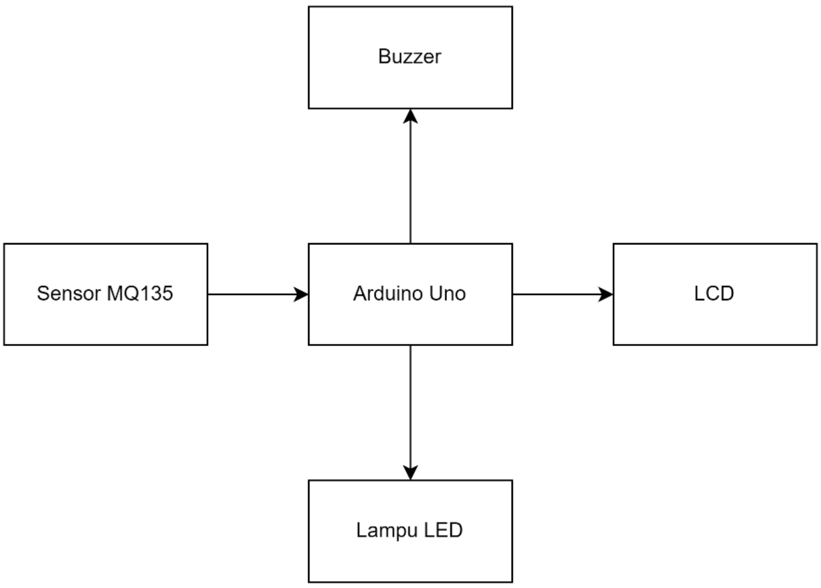

Figure 2. System Value Flowchart

The following is a description and stages of the designed tool series.

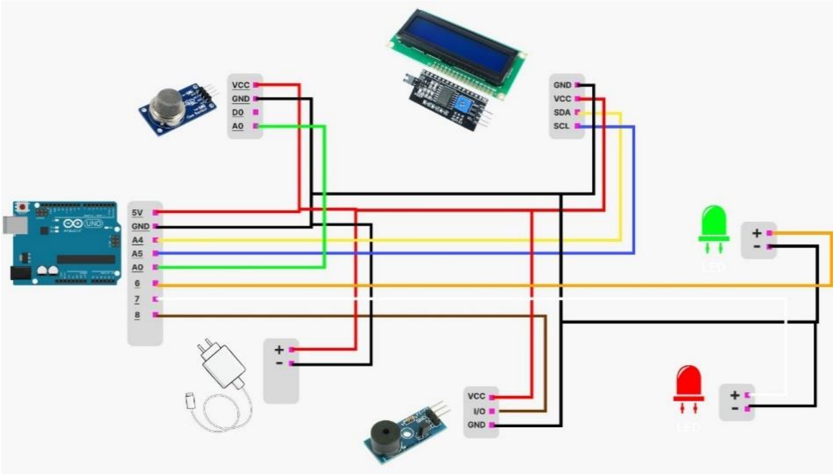

Figure 3. Tool Design Scheme.

RESULT AND DISCUSSION

Tool Design and Implementation

The design and implementation of a CO^2 measuring device using the MQ-135 sensor and Arduino Uno involves the following steps: connecting all components according to the circuit design, uploading the code to the Arduino, and testing the system to ensure that the device works properly (Amsar et al., 2020). The sensor device design process begins with the preparation of the MQ-135 sensor tool and materials, then the buzzer is connected to the Arduino Uno connector according to the circuit.

Figure 4. MQ-135 Sensor Circuit

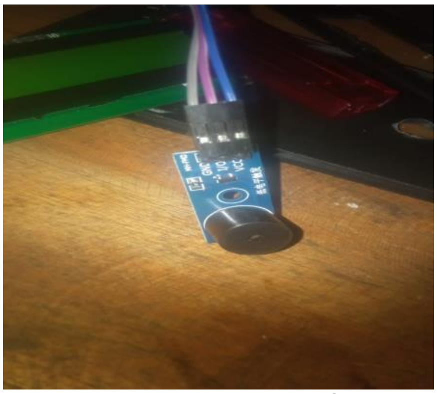

Figure 5. Buzzer as a CO^2 alarm

Next step, connect the LCD to the Arduino on the specified port according to the circuit that has been made. After all components are connected to the Arduino uno, the designed device will be visible.

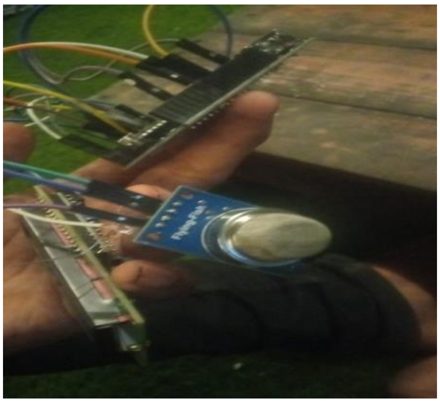

Figure 6. LCD to Arduino

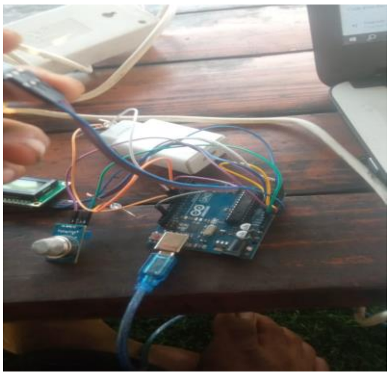

Figure 7. Complete components

After all the components are connected, the next step is to enter the program into the Arduino memory so that the device can function according to our wishes. Connect the Arduino to the laptop using the IDE cable that was included when purchased.

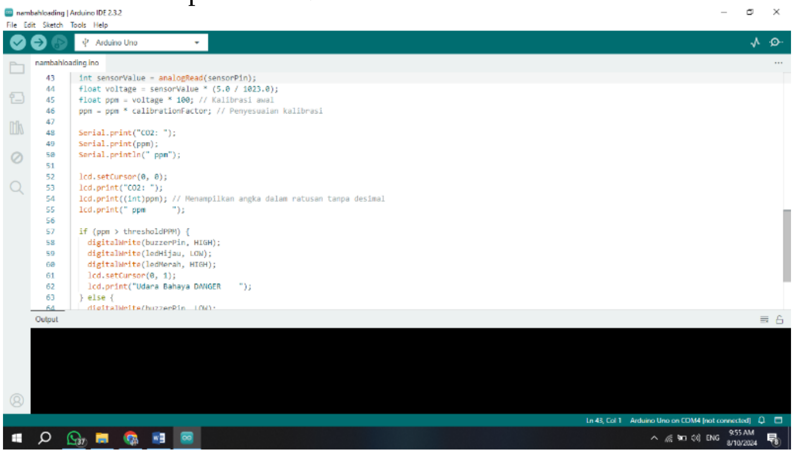

Figure 8. Code in the Arduino Application

After the program is entered, the next step is to test the device that has been created..

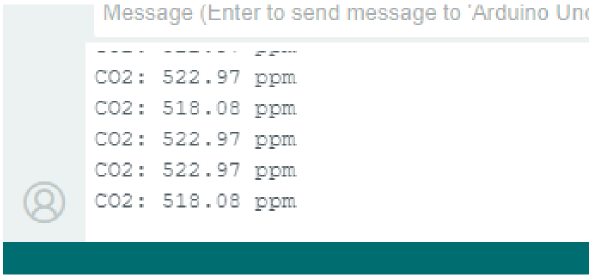

Figure 9. Display of test results in the Arduino IDE application

Figure 10. Display of LCD test results

After the program is entered, the next step is to test the device that has been created. The device will be put into a box to make it look neater and more attractive.

Figure 11. Overall view of the Research Tool

Sensor Tool Testing

Ha The test results show that the developed tool can detect CO^2 concentrations in various rooms with high accuracy.

1. Testing of Tools in the Islamic Boarding School Environment

Here are the test results in three different rooms at the first location of the Bahrul Ulum Main Boarding School on August 3, 2024.

a. Kitchen Room

Sample data was taken as many as 10 for the Kitchen Room to be able to determine the average indicator of Carbon Dioxide Gas levels. The following is a test table in the Kitchen Room.

Table 1. Test results in the Kitchen Room (ppm)

	Test Result Value	Comparative Tool	Indicator Description
Time 07.00	456	469	SAFE
	470	482	SAFE
	489	512	SAFE
	512	525	SAFE
	678	687	SAFE
Means	**521 PPM**	**535 PPM**	SAFE

b. Living Room

Sample data was taken at 5 points in the Kitchen Room to determine the average level of Carbon Dioxide Gas. The following is a test table in the Living Room.

Table 2. Test results in the Living Room (ppm)

	Test Result Value	Comparative Tool	Indicator Description
Time 09.00	340	378	SAFE
	355	478	SAFE
	390	420	SAFE
	420	410	SAFE
	460	447	SAFE
Means	**393**	**426**	SAFE

c. Bedroom

Sample data was taken at 5 points for the Kitchen to find out the average indicator of Carbon Dioxide Gas levels. The following is a test table for the Bedroom:

Table 3. Test results for the Bedroom (ppm)

	Test Result Value	Comparative Tool	Indicator Description
Time 23.00	420	452	SAFE
	435	415	SAFE
	450	420	SAFE
	470	453	SAFE
	480	466	SAFE
Means	**451 PPM**	**441 PPM**	SAFE

2. Testing of equipment in the Unwaha Environment

Here are the test results in three different rooms at the location of Kyai Wahab Hasbullah University, on August 4, 2024.

a. Laboratory

Sample data was taken as much as 10 for the Kitchen Room to be able to determine the average indicator of Carbon Dioxide Gas levels.

Here is the test table in the Laboratory.

Table 4. Test results in the Laboratory Room (ppm)

	Test Result Value	Comparative Tool	Indicator Description
Time 13.00	520	481	SAFE
	589	557	SAFE
	550	523	SAFE
	562	548	SAFE
	568	553	SAFE
Means	**557 PPM**	**532 PPM**	SAFE

b. Library

Sample data was taken as much as 10 for the Kitchen Room to be able to determine the average indicator of Carbon Dioxide Gas levels. The following is a test table in the Library Room, on August 8, 2024.

Table 5. Test results in the Library Room (ppm)

	Test Result Value	Comparative Tool	Indicator Description
Time 09.00	470	456	SAFE
	485	469	SAFE
	445	453	SAFE
	487	485	SAFE
	480	483	SAFE
Means	**473**	469	SAFE

c. Classroom

Sample data were taken as many as 5 points in the classroom to be able to determine the average indicator of Carbon Dioxide Gas levels. The following is a table of tests in the classroom:

Table 6. Test Results in the Classroom (ppm)

	Test Result Value	Comparative Tool	Indicator Description
Time 10.00	420	421	SAFE
	435	428	SAFE
	450	467	SAFE
	470	450	SAFE
	480	461	SAFE
Means	**451**	**445**	SAFE

3. Testing of Equipment in the Mosque Environment

Here are the test results in three different rooms at the third location, on August 5, 2024. Sample data was taken as many as 5 for the Kitchen Room to determine the average indicator of Carbon Dioxide Gas levels. Here is the test table in the Mosque Room:

Table 7. Test results in the Mosque Room

	Test Result Value	Comparative Tool	Indicator Description
Time 07.00	380	425	SAFE
	390	458	SAFE
	400	423	SAFE
	420	419	SAFE
	430	459	SAFE
Means	**404**	**436**	SAFE

Discussion

The test results at the three locations showed that the developed CO^2 sensor device was able to detect CO2 concentrations in various rooms with high accuracy. All measurements were in the "SAFE" category, indicating that this device is effective in monitoring air quality and ensuring that CO^2 levels remain within a safe range. In accordance with the opinion of Budiyomo (2001) that CO^2 content has an impact on environmental pollution.

The average PPM value recorded in each room showed that the CO^2 concentration was still below the established safe limit (1000 ppm). Although there were variations in ppm values in each room, none of the samples showed values above the safe limit (Daniel et al., 2023).

The developed device successfully demonstrated good performance in detecting CO^2 concentrations in various rooms. All test results showed that CO^2 levels at the tested locations were within safe limits. This indicates that this device is effective in monitoring air quality and can be used to ensure that CO^2 levels remain within a safe range. This tool can be a good solution for use in household environments and public places to maintain good air quality (Wahyudi & Purnomo, 2020).

CONCLUSIONS

Based on the test results, it can be concluded that the developed device for measuring CO2 concentration shows good performance compared to the comparison device in various rooms. This device successfully detects CO2 levels with adequate accuracy, as shown by consistent measurement results in each room. By using different colors on the graph, we can easily compare the results between the developed device and the comparison device. This study successfully achieved its objective by showing that the developed device can be used to monitor air quality in various rooms effectively. The main contribution of this study is to provide a practical solution for CO2 measurement that can be applied in both household and public environments.

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