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Design of the emission measuring equipment of air pollution index based on real time

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Abstract. This study aims to design a prototype of portable measuring instrument to measure the emission concentration of air pollution index and to easily access data from the portable measuring devices in real time. The model of this tool is compact using five sensors. The operating system of the sensor started from the power supply giving each voltage of 5 volts to the microcontroller, the sensor reads the concentration value of emissions in the air and the analogue data processed by a microcontroller converted into digital data. Microcontroller dispatch to digital data as output displayed on SD Card, TV, and LCD displays. The results of this study is the prototype of a practical emission measuring portable device with a small dimensions of 8 cm x 15 cm and low power usage. The emission concentrations displayed are PM10, SO₂, CO, O₃, and NO₂ via internet-based smartphones or laptops in real time.

1. Introduction

Air pollution is the condition of air in the atmosphere where one or more pollutants are in an endanger amount and concentration to the health of living things, damage property, and reduce comfort in the air. The main factors in the occurrence of air pollution are generally caused by industrial activities, motorized vehicles, and land burning activities. Fossils burning by some of these activities produce some polluting gas emissions released into the air. According to the Ministry of Environment RI, emission is a substance or component produced from an activity that enters or is put into the ambient air and can potentially pollute the air. This definition is applied especially for CO₂ pollutant concentrations which continued to increase by 7.10% in the period 2010-2014 [1].

In addition, 70% of urban air pollution is caused by motor vehicle activities [2]. Sulfur Dioxide (SO₂) emissions increase 85% and Nitrogen Dioxide (NO₂) has exceeded 100%, which is 357% in 7 years [3]. Ambient air quality in the city of Makassar especially around Urip Sumoharjo, AP. Pettarani, Sultan Alauddin, Jenderal Sudirman, and Ahmad Yani roads had been polluted by CO pollutants in dangerous and very unhealthy categories [3]. This is thought to occur due to an increase in motorized vehicles in the city of Makassar which indicates that air pollution is increasing.

Besides polluting the air, these substances can also interfere with human health. CO substances that enter and involved in the human body metabolism within blood can be toxic, then if exposed to NO_x levels in the long term can increase the risk of ARI, then Pb can cause excessive cancer in children, and smoke can cause irritation of the mucous membranes of the canal breathing and damaging the mucous membranes in the respiratory tract, hence causing bacteria to easily enter the body [4]. This was reinforced by an analysis from the International Energy Agency (IEA) in 2016 which suggested that pollution or air pollution responsible for the early deaths of 60 thousand Indonesians. In addition,



data from the World Health Organization (WHO) states that in 2016 there are more than 80% of countries in the world with air pollution conditions exceeding the threshold [5].

To determine whether the air is polluted or uncontaminated, it is necessary to measure the concentration of pollutants in ambient air, in order to obtain existing data. In Indonesia, air pollution is expressed by an index called the air pollution standard index (ISPU). Based on the device there are five types of pollutants which can indicate polluted or uncontaminated air. The five pollutants / emissions are PM10, SO₂, CO, O₃, and NO₂.

There are many measuring instruments that can be found, but to get a portable measuring instrument, the cost is very expensive and no tools can be found that can measure the five pollutants which are the basis for simultaneous analysis of air pollution. Therefore, a measurement instrument for CO emission concentration, as parameters of the air pollution index, is needed. The tool can be used as needed for measurement, monitoring, and research in real time, and has many advantages in terms of dimensions, practicality that is easily mobilized or low power usage. In this paper we will discuss the design of portable devices to measure CO emissions in real time.

Therefore, the recent study aims to design a device that is quite compact to be carried anywhere to be used to measure the levels of air pollutants in several desired places, or someone can monitor pollutant levels in the air via an internet-based smartphone or laptop. The operating scheme of the air sensor started from a power supply that provides a voltage of 5 volts each to the microcontroller and sensor. The sensor reads the value of pollutant gas compounds in the air and then the data is input to the microcontroller. The results of sensor reading in the form of analog data will be processed and changed by the microcontroller into a digital data, then the microcontroller sends digital data to the SD Card, TV, and LCD display and is displayed as output. Simultaneously, the microcontroller also sends data to the Wi-Fi module. The Wi-Fi module has been connected to a Wi-Fi router as IoT (Internet of Things) so that it can be monitored via a smartphone or PC (laptop / computer). When the results of reading the levels of pollutants received by the sensor exceed the specified quality limit, the microcontroller sends digital data to the buzzer and LED lights as a form of warning.

2. Method of design and development of portable tools

The method of research conducted in order to achieve the research objectives is described as follows.

2.1. Research work plan

This research began with a review of relevant literature with the research theme. Subsequently, the research work plan was designed which includes several stages. Stage 1 was a preliminary study related to the search for sensors for the five pollutants and supporting components needed; Stage 2 was a collection or order of the five sensors and supporting components; Stage 3 was the assembly of the sensor, supporting components, and programming; Stage 4 was the stages of testing and calibration carried out by third parties.

2.2. Location and Time of Research

This research was conducted in the Air and Noisy Laboratory of the Department of Environmental Engineering and the Department of Mechanical Engineering. The research was conducted within 6 months starting from April to September 2018.

2.3. Main and Supporting Components

The main components of the tool were sensors and microcontrollers. The installed air sensor is a sensor for pollutants PM10, SO₂, CO, O₃, and NO₂. The selection or determination of the microcontroller used was based on how easy it is to use and also as accurately as possible to read the input values from the sensor. Determining compatible sensors and selected microcontrollers, also considers how accurately the sensor reads pollutant compounds. In addition to the main components, the tool also used supporting components such as cables, pin connectors, LCDs, SD card modules, RTC modules, power regulators.

2.4. Programming

The program designing used the basic language C, divided into several parts of the program for each component, for example the program for each sensor, LCD, SD card module, RTC module, and wi-fi module and then merged into one.

2.5. Assembling / designing the main and supporting components

Assembling components was carried out by connecting each sensor to the microcontroller using a cable so that it becomes a single unit. The assembly scheme or design of all components is carried out as in figure 1.

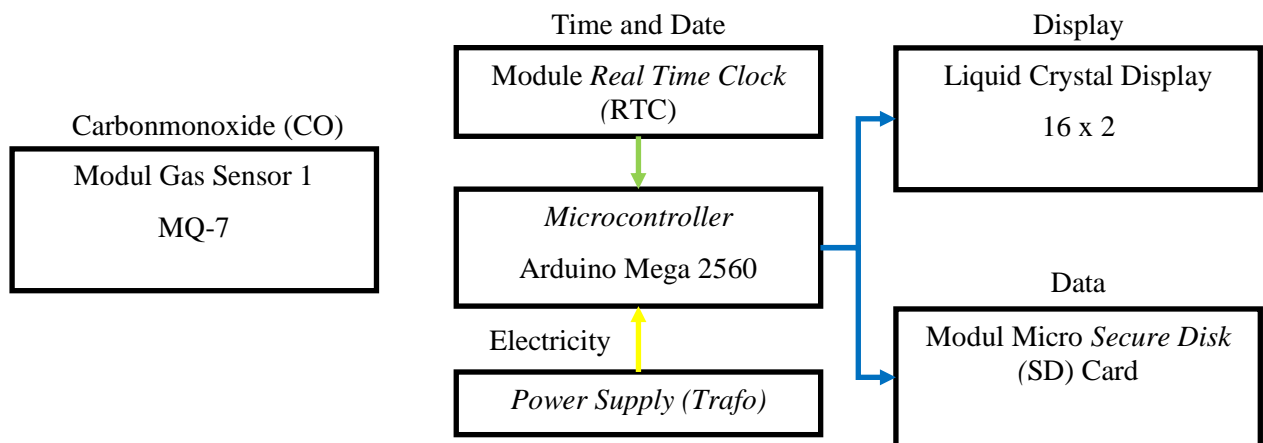


Figure 1. Flowchart the assembly of portable measuring device

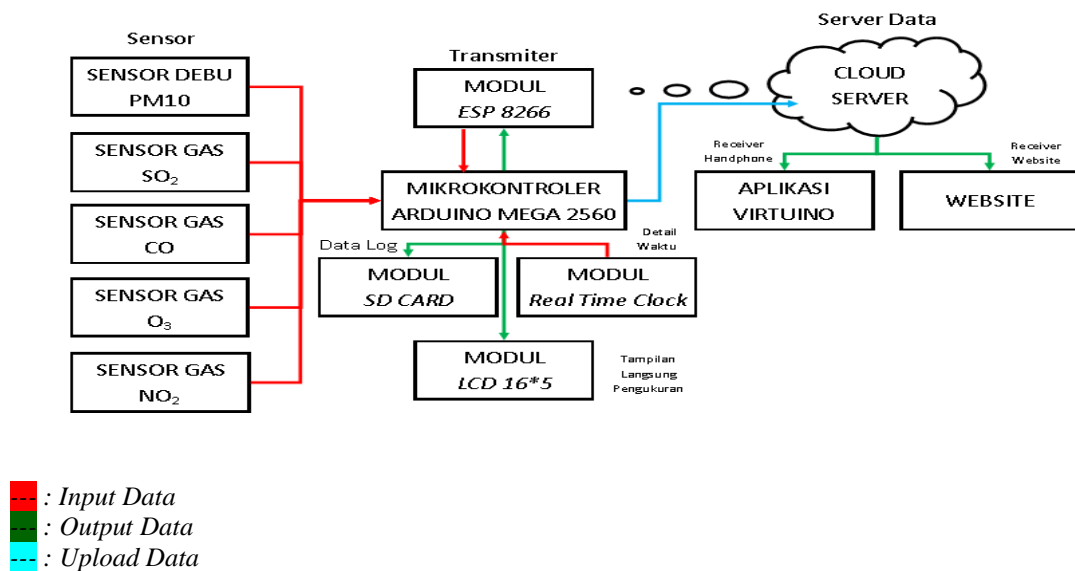


Figure 2. Circuit diagram of the portable devices

3. Results and discussion

3.1. Tool Series diagram model

The construction of portable tool devices based on the Arduino Mega 2560 microcontroller was based on a circuit diagram model as illustrated in figure 2 and connected to the IEEE 802.11b WLAN wi-fi network to the cloud server that will be forwarded to the recipient.

Data received by the five sensors will be transmitted through the ESP 8266 module to the cloud server using the IEEE 802.11b wifi network. In addition to the data being forwarded to the recipient and displayed, the data will also be stored in the data logger or SD Card module. Data stored on the SD Card module is anticipated if there is data lost during shipping. Data is read in real time and can be seen on the display on the LCD module. Furthermore, from the illustrated circuit diagram of portable tool devices in figure 2, a series of tools is used using the main equipment and other supporting tools as can be seen in figure 3.

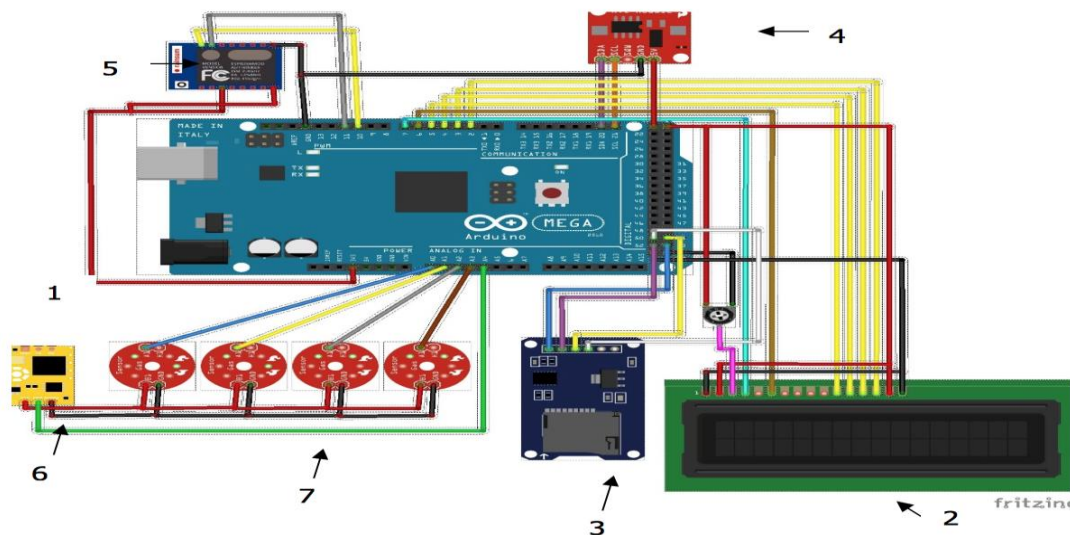


Figure 3. Main equipment series and support of portable device

Information:

1. Microcontroller board (Arduino).
2. LCD module.
3. SD Card Module.
4. RTC Module.
5. ESP01 8226 (WiFi) module.
6. Dust Sensor Module.
7. Module gas sensors (CO, O₃, NO₂, SO₂) and PM10 dust

In figure 3, the cable lines are connected to the microcontroller of each module that is arranged. The form of this measuring instrument is obtained from the assembly carried out based on the circuit diagram as shown in Figures 2 and 3 and set on the PCB (Printed Circuit Board) as in figure 4. Operation of this device uses a 9 Volt 2 Ampere and Adapter power source then connected to the port that is directly connected to Arduino Mega 2560. The way to use Arduino mega 2560 is to connect the adapter to a power source and to the port that is black or using USB type A. After that it is connected to a series of devices. All components of both the main tool and supporting equipment are assembled on the PCB to form a small and mobile measurement tool, as shown in figure 4, PCB dimensions are 8 cm x 15 cm.

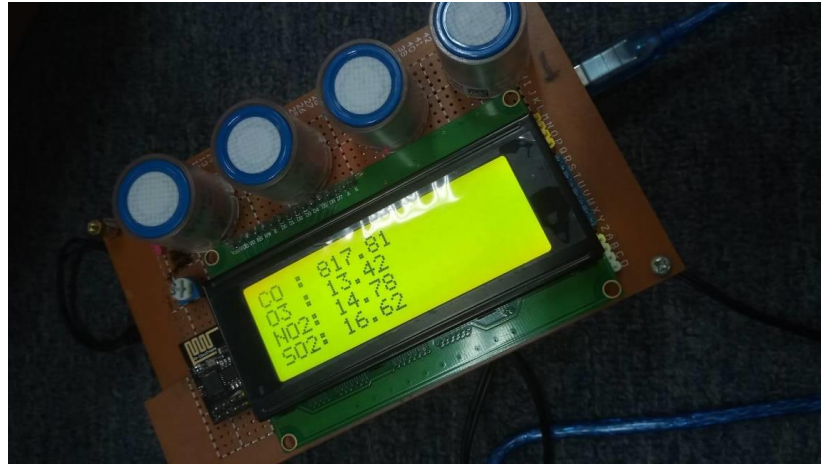
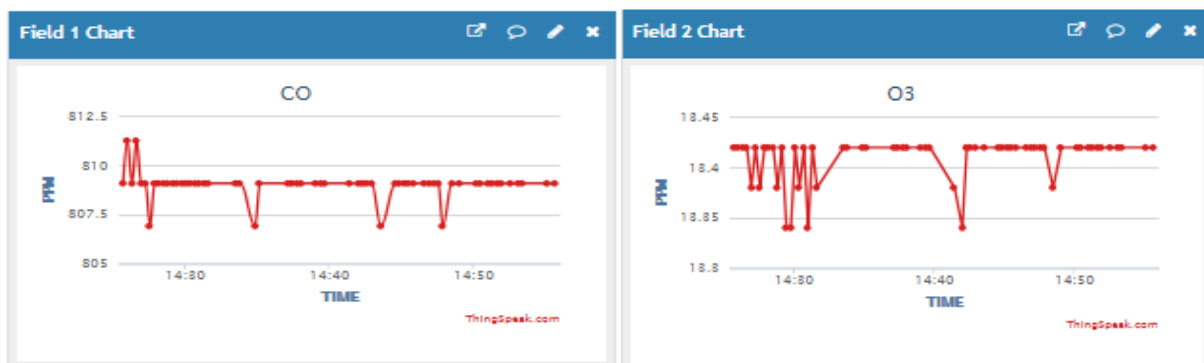


Figure 4. Built portable tools

3.2. Built-in device measurement display

The device discussion will be carried out by transmitting sensor data to the Cloud server and data will also be stored in the Data logger.

3.2.1. *Sending data to the cloud server.* Presentation of data from the cloud server *thingspeak.com* displayed the results of sensor readings in graphical form. Readings were carried out for 24 hours. The reading of CO and O₃ pollutants in ppm units displayed in a graph between the concentration of pollutants and the time of observation as shown in figure 5.

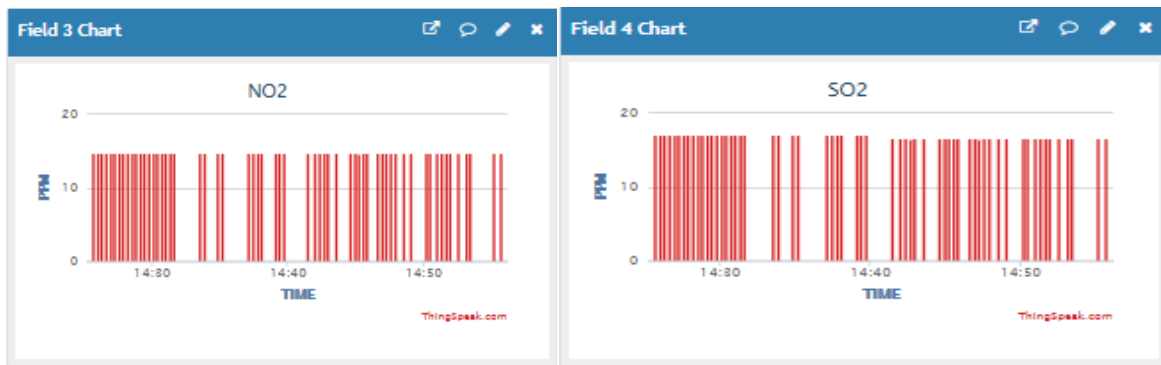


a. Pollutan CO

b. Pollutan O₃

Figure 5. Display CO and O₃ pollutants on the monitor on a smartphone or TV

Figure 6 shows the display of NO₂ and SO₂ pollutants in units of ppm which can be accessed on a smartphone or TV.



a. Pollutan NO₂

b. Pollutan SO₂

Figure 6. Display of NO₂ and SO₂ Pollutants on the monitor on a smartphone or TV

3.2.2. *Storage on data logger.* Besides being sent to the web server, the sensor data is also stored offline on the data logger. Sensor reading data along with data retrieval time are provided in the .txt extension file so that to open it we can use Microsoft Excel or use Notepad. Example Samples of portable tool test results that have been done can be seen in figure 7.

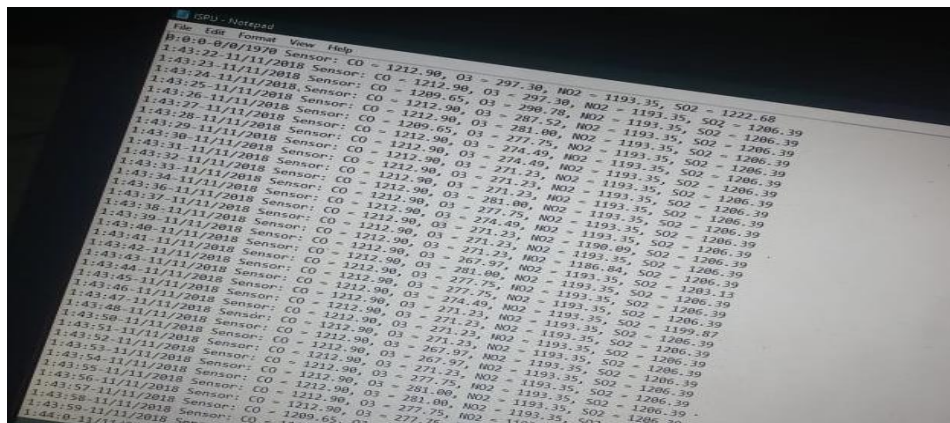


Figure 7. Display Data Logger stored on SD Card.

4. Conclusion

After designing and testing portable measuring devices, several conclusions can be described:

1. The portable Air Pollution Index monitoring devices based on Arduino Mega Microcontrollers Mega 2560 on IEEE 802.11b Network was more flexible with a small size of 8 cm x 15 cm and mobile.
2. If there is an error in the transmission system and the portable air pollution index monitoring device based on the Arduino Microcontroller Mega 2560 does not get enough internet network to upload data, then a backup system is available using the SD card as a data logger.
3. The power used by this tool were from batteries/storage batteries and lasts less than 3 days, hence a further research is necessary to test the use of other renewable resources such as solar cells or windmills.

Acknowledment

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