Design of Prototype System for Monitoring Air Quality for Smart City Implementation

Yuni Aryani Koedoes¹, Samuel Jie¹, Muh. Nadzirin Anshari Nur¹, Bunyamin¹, Alwan Astari¹
¹Department of Electrical, Faculty of Engineering, Universitas Haluoleo, 93232 Kendari, Sulawesi Tenggara, INDONESIA

*Corresponding author’s e-mail: yuniarafkendari@gmail.com

Abstract. Air pollution can be caused by natural sources and human activity. Now many say the polluted air around us. Carbon monoxide (CO) and carbon dioxide (CO2) is a parameter for determining the quality of clean air and polluted. If levels of these two substances excessive inhaled by humans, can be detrimental to health. By using the Arduino Mega 2560, air quality monitoring system in this study using LM35 sensor to determine the temperature of the air, MQ-7 sensor to determine the levels of CO and sensor MQ-135 to determine the levels of CO2 that is in the room. Sensor MQ-7 will be equipped with red and green LED indicator as the level of air quality is polluted or not polluted. If the levels of CO < 5 ppm, the green LED turns on and vice versa CO > 5 ppm, the red LED lights up. Likewise, CO2 levels <350 ppm, the green LED turns on and vice versa CO> 350 ppm, the red LED lights up. Research and simulation results show that the system works well. In the application of smart city, one of the important parameters is the monitoring system, in this research will be designed air quality monitoring system for the application of smart city.

1. Introduction
High levels of air pollution through a good smoke pollution from vehicles, factories as well as the impact of forest fires has increased especially in the big cities, along with the problem yet so real efforts to prevention through early warning against air pollution. Air pollution can be caused by both natural sources originated from human activities. Type-the type of air pollutants is based on the raw quality of air inhaled daily, according to the Government Regulation Number 41 year 1999, which include: sulfur dioxide (SO2), carbon monoxide (CO), nitrogen dioxide (NO2), oxidants (O3), carbon and hydrogen. (HC), PM 10, PM 2.5, TSP (dust), Pb (Lead), dustfall [1]

Health effects from air pollution can get into the body through the respiratory system. Away the penetration of substances pollutants into the body depends on the type of contaminant. Larger particulates can be stuck in the upper respiratory tract, while small-sized particulate and gas can reach the lungs. From the lungs, pollutants are absorbed by circulatory system health effects the most common are RESPIRATORY (acute respiratory tract infections), including, asthma, bronchitis, and other breathing disorders. Impact on crop plants that are grown in areas with high levels of air pollution can be disrupted its growth and prone to disease, such as chlorosis, necrosis, black spots2.

Carbon monoxide (CO) and carbon dioxide (CO2) is the parameter to determine the air quality clean and polluted. If the levels of these substances are excessively inhaled 2 by humans then can impair health. Carbon monoxide (CO) is produced by the combustion process is not perfect from the carbon-based material, such as wood, coal, fuel oil and other organic matter carbon dioxide resulting from the combustion process for example burning plastic, paper and also smoke cigarettes as well as on the larger case is forest fires[2]

Ambient air quality of a region is determined by the power the area's nature as well as support a number of sources of pollution or contamination loads from existing resources in the area. In some developed countries have implemented system monitoring the air, such as South Korea and Taiwan use applications with IoT collect data environment that is massive as well as identified a number of particles/hazardous substances [3] Substances emitted by the source of the contaminant into the air and
could affect air quality among other things the gas Nitrogen oxides (NOx), Sulfur dioxide (SO2), dust as well as Lead (Pb) in the dust.

| Parameters       | Clean Air  | Polluted Air |
|------------------|------------|--------------|
| Particle Materials| 0.01 – 0.02 mg/m³ | 0.07 – 0.7 mg/m³ |
| SO₂              | 0.003 – 0.02 ppm  | 0.02 – 2 ppm   |
| CO               | < 1 ppm     | 5 – 200 ppm   |
| NO₂              | 0.003 – 0.02 ppm | 0.02 – 0.1 ppm |
| CO₂              | 310 – 330 ppm | 350 – 700 ppm |
| Hydrocarbons     | < 1 ppm     | 1 – 20 ppm    |

Often occurs in the middle of the community particularly the area vulnerable to air pollution especially in the big cities will implement smart city may not necessarily be directly perceived society takes long enough that the air in the polluted, it These can be detected when many societies have been hit by the effects of the pollution for example respiratory disease, the limited views and more. With the conditions and problems of the air quality monitoring system is needed to anticipate the impacts of air pollution, on the concept of smart city one of the aspects that can be applied is system monitoring, by it that researchers are designing a prototype system for monitoring air quality for the application of smart city.

2. Methods and Literature

Until recently, research and development of monitoring system for air quality continues to be done, such as research conducted with the title “tool Monitors air pollution From carbon monoxide Gas (CO) at Room AT89S51 Microcontroller-based”. The study designed a system of monitoring the levels of pollutant gases using gas sensor TGS 2442 are sensitive to carbon monoxide gas and transcription results will show up in the LCD the difference with the research that the researcher will be minutely present on the sensors are used i.e. only using the TGS 2442 whereas researchers MQ-7 and not just the levels of CO are measured but CO₂ levels and temperature of the room [4].

Other research is system monitor air quality with the title "the making of Gauges the level of air pollution using AT89S51 Microcontroller-based sensor TGS 2600" research consists of a microcontroller circuit sensor TGS AT89S51, 2600, Op-Amp and LCDS as appearance. This tool works when detecting the levels of carbon monoxide gas is passed through the sensor, its output voltage to be converted by the Op-Amp to be processed into the microcontroller and LCD in order to make it easier to display readings [5].

Based on some research that has been done before, then on the research will be carried out development to add some sensors for more versatility. Development is done using the on-board Arduino Mega 2560 to simplify the system. This is possible because the Arduino Mega board has been integrated with an ATmega168 microcontroller and there have been pin-a pin that contains all required by the microcontroller. In addition, the Arduino Mega 2560 also have special applications with programming language has been simplified, making it easier to do the development of the system.

3. Result and Discussion

3.1 System Design

The System Monitors the air quality automatic monitoring system is composed using the LM35, MQ-7 as well as MQ-135 and 4x20 LCD display by utilizing the Arduino Mega 2560, sensors and LCD 4x20. Block diagram of the system listed in Figure 1.
Figure 1. Block Diagram of the system of air quality Monitoring

Figure 1 describes an overview of the design of the air quality information systems are designed. The system consists of several parts which are connected in such a way so as to form a single unity of the systematic work function. The main part of the system is the Arduino Mega 2560 that serves as the central control system. Input on the Arduino consists of LM35 temperature sensor probes as the MQ-7 as the quality of the monitor co., and sensor MQ-135 as the quality monitoring of CO2 in the room.

The output of the Arduino Mega i.e. LCD 4x20, LCD 4x20 function to display information the room temperature and air quality levels of CO and CO2 in the form of a value from the sensor reading of results. LCD 4x20 is part of the output of the Arduino which is automatically read and the monitoring of indoor air quality. The ability of the system to monitor air quality is highly dependent on the performance of the sensor. The function of the automatic control system that is owned by the air quality monitoring function which allows we can monitor air quality with air so that we feel safe and good if bad can be avoided and anticipated.

3.2 System Implementation

In this section will be discussed regarding the design of a series of port, results of implementation tools, testing and analysis of the test results. The purpose of the test is done to find out the extent to which performance results of design that has been discussed, as well as to know the success rate of each specification system. Testing conducted include testing against the sensor-sensor is used, LEDs as air quality information, and display on the LCD.

Figure 2. Implementation of Air Quality Monitoring System

3.3 Design of the circuit at the Port the Arduino Mega 2560

The design of the overall system series on the port the Arduino Mega 2560. In this system there are several port circuit subsystem, ranging from sensor-sensor is used, on display on the LED and LCD 4x20.

Figure 3. Designing the overall system series on the port the Arduino Mega 2560
3.4 Designing on Sensor LM35, MQ and MQ-135
This is a design of the sensor LM35 series, MQ and MQ-7-135 on the Arduino Mega 2560 and equipped its configuration table.

| Sensor  | Pin Sensor | Pin Arduino Mega 2560 |
|---------|------------|----------------------|
| LM35    | Vss        | 5 V                  |
|         | Vout       | Pin A0 (Analog Input) |
|         | GND        | GND                  |
| MQ-7    | Vcc        | 5 V                  |
|         | Aout       | Pin A1 (Analog Input) |
|         | Dout       | -                    |
|         | GND        | GND                  |
| MQ-135  | Vcc        | 5 V                  |
|         | Aout       | Pin A2 (Analog Input) |
|         | Dout       | -                    |
|         | GND        | GND                  |

3.5 Design on the LED
Here is the design of a series of LED as an indicator of air quality polluted and unpolluted on Arduino Mega 2560 and equipped its configuration table.

| LED  | LED  | Pin Arduino Mega 2560 |
|------|------|----------------------|
| LED 1 (Green) | Positif - Resistor | Pin 2 (PWM) |
|       | Negatif | GND                  |
| LED 2 (Red)  | Positif - Resistor | Pin 3 (PWM) |
|       | Negatif  | GND                  |
| LED (Green)  | Positif - Resistor | Pin 4 (PWM) |
|       | Negatif  | GND                  |
| LED 2 (Red)  | Positif - Resistor | Pin 5 (PWM) |
|       | Negatif  | GND                  |

3.6 Design on the LCD 4x20
This is the design of a series of LED as an indicator of air quality polluted and unpolluted on Arduino Mega 2560 and equipped its configuration table.

Figure 4. system arrangements of LCD Design 4x20 on port the Arduino Mega 2560
4. System Testing

4.1 Testing system at Normal air

On testing was performed against the normal air, not polluted by smoke.

From the results of testing the normal air, it appears that the system is running well according to the instructions.

4.2 System testing using MQ-7 sensor

In this test, researchers will simulate indoor air quality with exhaust emissions on the motor. Exhaust emissions on the motor are carbon monoxide substances whose levels can be detected by the MQ-7 sensor.

From the test results above it can be seen that CO levels in exhaust emissions are 5.68 ppm and the indicator LED on the MQ-7 sensor is red and indicates that the air quality is contaminated. In this test, researchers will simulate the quality of air in a room with carbon. Wood is one of the carbon substances. Smoke from burning wood is a carbon monoxide substance whose levels can be detected by the MQ-7 sensor. From the test results, it can be seen that CO levels in wood burning smoke are 5.20 ppm and the indicator LED on the MQ-7 sensor is red and indicates that the air quality is polluted.

4.3 System testing using MQ-135 sensor

In this test, researchers will simulate indoor air quality with cigarette smoke. Cigarette smoke is one of the carbon dioxide substances whose levels can be detected by the MQ-135 sensor.

From the test results above it can be seen that the CO2 level in cigarette smoke smoke is 235 ppm and the indicator LED on the MQ-135 sensor is green and indicates that the air quality is not polluted. In this test, researchers will simulate indoor air quality with paper burning smoke. Paper burning smoke is one of the carbon dioxide substances whose levels can be detected by the MQ-135 sensor,
From the test results, it can be seen that the CO2 level in the paper burning smoke is 206 ppm and the indicator LED on the MQ-135 sensor is green and indicates that the air quality is not polluted.

4.4 Testing the system using an LM35 sensor

4.4.1. Testing 1

In this test, researchers will simulate indoor air temperature with fire as a heat temperature that can be detected by an LM35 sensor. By simulating with fire the researcher will know the sensor works.

Figure 8. Testing of LM35 sensors after being tested with fire and display on the LCD

From the simulation results, it can be seen that after the LM35 sensor after being simulated with fire, the temperature on the LCD increases from 36.66°C to 39.10°C. This indicates that the LM35 sensor works because the temperature has increased.

5. Conclusion

From the results of testing and analysis system of the author's conclusion is then Informed air quality can be monitored directly by human beings through LED 4x20 LCD screen and as the charge indicators will, humans can know the levels of CO, CO2 and temperature indoors so can benefit additionally Information level air quality polluted and unpolluted knowable through the red and green indicator LEDs, from the results of the simulation levels of CO exhaust emissions amounted to 5.68 ppm and smoke wood-burning of 5.20 ppm, so that indicates that both the contaminated air, CO2 levels of simulated results with cigarette smoke and paper gets results that can function properly, from the results of testing of prototype can run well and for implementation at smart city needed further development especially on the device online as Internet of Things, and from the results of this research, the application of this prototype more appropriate in use at home with the smart home concept is applied to the system before the smart city

References

[1] Parameter Pencemar Udara dan Dampaknya Terhadap Kesehatan, http://www.depkes.go.id/downloads/Udara.pdf, access date 11 Maret 2018.
[2] Tomie Hermawan Soekamto, David Perdanakusuma. Intoksikasi Karbon Monoksida, Jurnal, SMF Ilmu Beda Plastik Universitas Airlangga, access date 28 Agustus 2018.
[3] Monitor Kualitas Udara dengan IoThttp://www.smartcityindo.com/2018/01/smart-city-monitor-kualitas-udara.html access date, 29 september 2018
[4] Farli Rizki. Alat Pemantau Polusi Udara Dari Gas Karbon monoksida (CO) pada Ruangan Berbasis Mikrokontroler AT89S51 [Skripsi]. UPN Jatim. 2011.
[5] Vadlya Maarif, Nuzul Iman Fadillah. Pembuatan Alat Pengukur Tingkat Polusi Udara Berbasis Mikrokontroler AT89S51 menggunakan sensor TGS 2600 [Seminar Nasional ke-9]. Amik Bina Sara Informatika Purwokerto.
[6] Buletin Who Mukono, 2005.
[7] Arduino. Introduction To Arduino {Online}. Italy: Arduino https://www.Arduino.Cc/En/Main/Arduinoboardmega2560, access date 29 Juli 2016
[8] Roberts, M. Mc, 2009, Arduino Started Kit Manual, Earthshine Electronics.
[9] Nur N. Alat Ukur Suhu Otomatis Berbasis Mikrokontroler ATMega 8535 dengan Penampil LCD [Tugas Akhir]. Medan: Universitas Sumatera Utara; 2012.