Dust Sensor

SIRIWARDENA S.J.
Department of Electrical and Electronic Engineering
University of Peradeniya
Srilanka
e19377@eng.pdn.ac.lk

MAHANAMA M.G.S.U.
Department of Electrical and Electronic Engineering
University of Peradeniya
Srilanka
e19233@eng.pdn.ac.lk

SERASINGHE K.T.M.L.S.
Department of Electrical and Electronic Engineering
University of Peradeniya
Srilanka
e19367@eng.pdn.ac.lk

Abstract*— The goal of this project is to create a sensor that can measure the amount or size of dust in the air. It is also capable of detecting any microparticle, including aerosols and droplets that are carried to the test area by a deep exhalation. This works under the principle of light scattering. When light from the IR LED reflects off particles moving through the hole of the test space chamber, the photodiode picks them up and generates a voltage. The IR sensor circuit of this sensor is powered by an Arduino, which is also used to program the sensor module to output data. To obtain the result, this microcontroller converts the analog voltage provided by the sensor to digital data.

Keywords—sensor, light scattering, chamber, dust

I. INTRODUCTION

The goal of the project is to create a dust concentration measuring sensor that primarily measures dust levels in the environment. The research was conducted about several dust sensors such as optical dust sensors, laser particle sensors, digital and universal particle concentration sensors etc. which uses principles such as optical sensing, beta ray attenuation, and laser scattering principle. availability and cost of components were taken highly into consideration. The laser scattering principle and optical sensing principle is highly used in many dust sensors due to commercial reasons. The sensor designed from the principle of laser scattering was less accurate since it was very much sensitive to light that entered the test space as it use an LDR. Therefore, designing an optical dust sensor was taken into consideration.

IR sensor module is used to detect the dust particles and the intention was to observe the variation of the output voltage. A microcontroller is used to power up the circuit and to give the output to the computer. This sensor's intended use is to introduce smoke or dust particles into the testing environment and then calibrated them to detect the concentration or particle size.

II. INITIAL SPECIFICATION

It is unable to find the initial specification of our sensor because there are lots of difficulties that occur when calibrating the sensor.

III. METHODS

A. Principle of operation

The air enters through the air inlet where a light source (Infrared emitting diode) illuminates the particles, and the scattered light is transformed into a signal by a photodiode. These signals are processed to get the particle concentration. The intensity of the scattered light depends on the dust particles. More the dust particles in the air, the greater will be the intensity of light. Output voltage at the Arduino_IN pin of the sensor changes according to the intensity of scattered light between 0 - 5V.
Based on the scattering principle of light, the working principle of the dust particle sensor was developed.

In this way, the relative attenuation rate of the incident light passing through the concentration field to be measured can be obtained. According to the algorithm and calibration method, the dust concentration can be obtained by counting the real-time particle number concentration. Particle size also can be obtained by the time period in which output voltage lasts.
The structure consists of the following parts, an infrared light-emitting diode, resistors, a potentiometer, and a photodiode, when the airflow through the intersection area of the optical axis intersects with dust, dust-reflected infrared light, the photodiode can detect the reflected light, the dirt in the air even can detect very small particles, such as Incense stick smoke.

B. Circuit diagrams

This sensor has two main parts.

- IR LED
- Photodiode

This circuit contains resistors of suitable values.

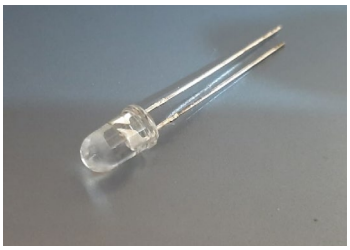

Fig.01. IR LED

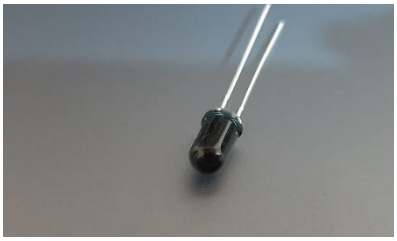

Fig.02. Photodiode

D1 -IR LED
D2 -Photodiode
R1, R2 -Resistance Values

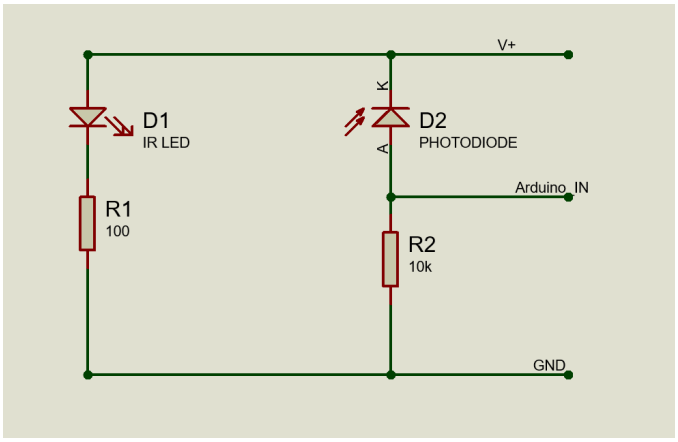

Fig.03. Circuit Diagram

The circuit needs 5V. The 5V is Supplied by the Arduino board. The Arduino_IN port is Connected to the analog port in the Arduino board.

C. Air Chamber

The air chamber is designed by using AutoCAD software and printed from a 3D printer. When designing the air chamber, the inside of the chamber is coloured black colour to minimize the reflection of the IR light. Also, the photodiode is placed at the point where the maximum scattered light can be captured.

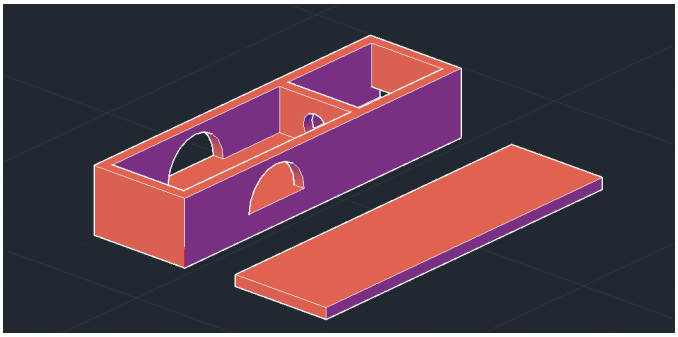

Fig.04. 3D Model

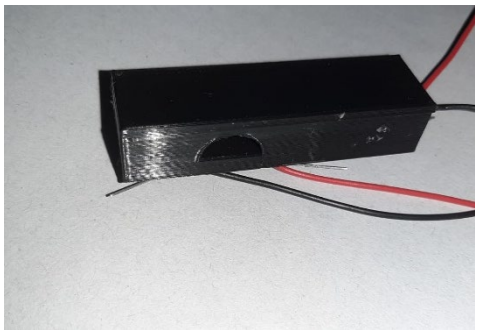

Fig.05. Outside Appearance of the Air Chamber

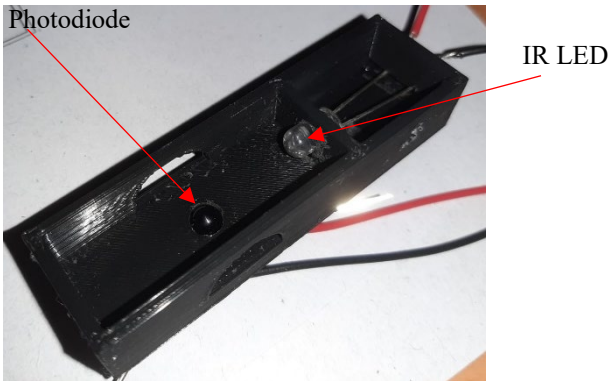

Fig.06. Inside of the Air Chamber

D. Sensor module

For the test sample Incense stick smoke is used to test our dust sensor.

The dust sensor is set up to let flow the smoke through the air chamber.

Fig.07. Sample testing Setup

Then the voltage reading is taken with the corresponding time. After that, the Voltage reading, and the corresponding time are plotted using MS Excel. This is the plot that is obtained from our dust sensor.

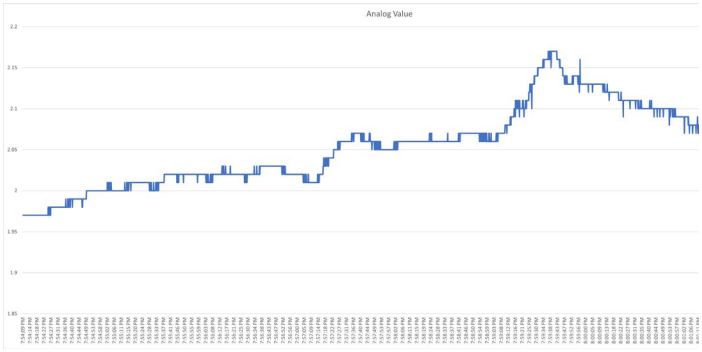

Fig.08. Variation of Output Voltage vs Time

IV. CALIBRATION

For this study, a common aerosol test chamber was used for the calibration of dust sensors and an aerosol source of stick smoke is used. The intention was to get the outputs of the standard dust sensor over a period of time and the designed dust sensor and to map the output results to compare the curves. The standard dust sensor gives the output in particle size (pm) and the designed sensor's output was in voltage(V). The plan was to compare the results through mapping and test the accuracy precision and range and to calibrate the designed sensor to read the output and to evaluate the particle size of the particles that entered the test space from the output voltage (V) as a function of particle size in pm.

The challenge:
The standard dust sensor gives the output in 5-minute gap intervals. And the range of the particle size of that standard dust sensor is evaluated so that the particles of stick smoke will result in the saturated condition of the standard sensor. Also, to give the output results from the designed dust sensor, the particles should exactly go through the test space of the chamber. Therefore, there was not enough evidence that the particles exactly went through the chamber hole since both sensors are kept inside a closed space (box) with dust particles. Due to these reasons, the calibration was unsuccessful.

An example of a successful calibration of a dust sensor model is shown below.
Below shows Measurement of the mass concentration of calibrated GP2Y1010AU0F (Sharp) dust sensor model in comparison to the standard dust sensor DustTrak. There we can see Measurements of the model GP2Y1010AU0F after its calibration is in good agreement with the mass concentration measured by DustTrak.[1]

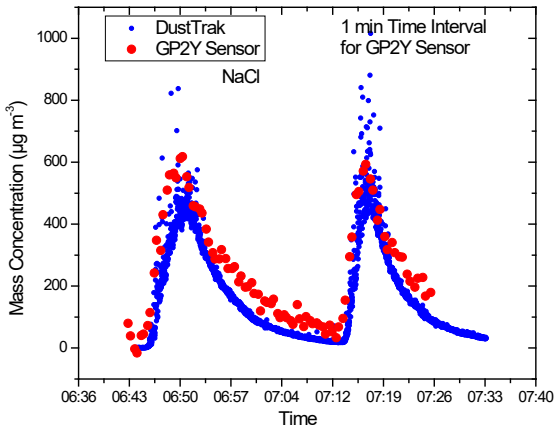

Fig.09. Measurement of the mass concentration of calibrated GP2Y1010AU0F (Sharp) dust sensor model in comparison to the standard dust sensor DustTrak.

V. DISCUSSION

A. Difficulties

1) *Method selection*: In the Project Proposal report, there are two possible methods mentioned to measure dust particles. Beta Ray Attenuation method and Scattered Light method. Since the Beta Ray Attenuation method is radioactive and expensive as well as the Scattered Light method is cheap, the Scattered Light measuring method is chosen as the best method to implement the dust sensor.
2) *Finding a way to measure the dust concentration by infra-red waves*: Initially, many research papers, journals, science

articles, and resource videos are used as a reference to get a better knowledge about infra-red wave dust measuring. With the help of these resources, the Scattered Light method is found to implement the sensor using infrared waves. The primary operations of this sensor are described above.
3) *Designing the sensor circuit:* An Arduino Uno is used to give power to the circuit and to read the output voltage. An IR LED bulb is used to send the light beam and a photodiode is used to receive the scattered light. 100 ohms resistor is used for the safety of the IR LED and 10k ohms resistor is worked as a load for the circuit. The circuits are designed according to the datasheets of the components.
4) *Calibration*: Sensor calibration is not completely done because values from a standard dust sensor were unable to be taken.

B. Strengths

1) *Size and Weight*: The sensor module setup size and weight are very small. Therefore, the user can easily handle it.
2) *Installation*: No need for knowledge about electronics and sensors to install it.
3) *Ability to sense small particles*: Even Incense stick smoke can be sensed.
4) *Real-time values*: The sensor is measuring real-time values and plots a graph with time.

C. Weaknesses

1) Dust particles must go straight through the holes. Otherwise, it cannot sense.
2) *Saturation*: Since the air chamber is very small, When the air chamber is filled with smoke it gets saturated.

D. Comparison

This sensor has an easy installation setup and a user-friendly operating system compared with other sensor products. Users can easily identify the dust particle concentration in live time.

VI. CONCLUSION

A dust sensor is a good electronic device that measures dust concentration and dust particle size to get measurements of air pollution. The infrared sensor method was used as the basic principle for this sensor. Real-time dust concentration is given from the sensor.
The successful development of this economically cost-effective module would be useful in the environmental safety area.
The main purpose behind this project is to learn about how the real-time application works, how to communicate various electronic devices and their outputs, how to combine them, and finally by completion of this project our ability as an engineer is boosted.

VII. ACKNOWLEDGEMENT

We would like to convey our heartful gratitude to Dr. Ruwan Ranaweera and Dr. W.A.N.I. Harischandra for their tremendous support, advice, and assistance throughout the project. Also, we would like to express our special thanks to our batchmates, for their useful advice and suggestions. We are also grateful for the support given by our lab assistants and lab instructors for the completion of the project. Notwithstanding the fact that any faults or errors made by us should not reflect negatively on these respected individuals

REFERENCES

[1] Ghamari, M., Kamangir, H., Arezoo, K. and Alipour, K. (2022). Evaluation and calibration of low‐cost off‐the‐shelf particulate matter sensors using machine learning techniques. IET Wireless Sensor Systems, 12(5-6), pp.134‐148.doi:https://doi.org/10.1049/wss2.12043.