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Design and Fabrication of IoT Enabled Air Purification System

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Abstract: *In most metro centres, the incidence of dust pollution is rapidly growing, necessitating the installation of a system that can filter the air. This study offers the concept of a smart air purifier for residential settings, as well as a practical physical model. The filter employed in this case is a HEPA filter, which captures solid pollutants and cleanses them, reducing VOC pollutants more effectively than other purifiers on the market. This purifier is controlled by an IoT system, which allows it to run automatically and save energy while also displaying real-time data on impurities in the environment.*

Keywords: IoT , HEPA filter, optical dust sensor, Arduino Uno

I. INTRODUCTION

Air pollution is growing as a result of increased industrialisation and civilisation. Dust particles will always be present in homes, workplaces, and other locations. The World Health Organization recently issued a study on air quality, warning that it is dangerous to human health, citing more than 5 million premature deaths caused by air pollution in the environment.

Sources of Air pollution and effects:

Every day in the modern period, there is progress and changes in industrialization, offices, and housing. The majority of the air in Delhi, like in other metro cities, is contaminated by car pollution. numerous sectors of industrialisation and development Dust, pollens, smoke, carbon dioxide, and other pollutants are found in the air, and these pollutants are the most deadly and severe, causing climate change and life-threatening illnesses.

Air pollution causes minor difficulties in humans such as itchy eyes, sneezing, and headaches, and may also be a major contributor to allergies and life-threatening asthama. These have serious health consequences, including stroke, lung cancer, and heart disease, as well as ozone layer degradation. Indoor air is a hundred times more toxic than outside air, according to the United States Environmental Protection Agency (EPA). To appropriately maintain air quality, accurate and efficient indoor air monitoring is required. It also causes ozone layer depletion, which causes stroke, lung cancer, and heart disease.

II. OBJECTIVE

To solve the problems of air pollutants as mentioned above, a smart air purification system will require to work on this issue. The objective of our project is to reduced the power consumption by implementing microcontroller and sensor. This sensor will sense the presence of dust and smoke in the environment and thereby turns on the air purifier automatically when the value exceeds threshold value . Due to the presence of sensor in this system it can be operated only at the time of necessity thus can save electricity and also keeps space clean and also monitors air quality in the environment.

III. LITERATURE SURVEY

Previous work in this topic was published in [1], in which the author attempted to minimise energy usage by allowing IoT-based systems and sensors and displaying real-time sensor data analytics on a mobile device. Similarly, the author of another research [2] has supplied a circuit diagram of sensors that compares the quality of air in the environment to the Air Quality Index and switches on the purifier as needed.

The following study [3] summarises an IoT-based interior air quality monitoring system for monitoring ozone concentrations near a photocopier. The IoT device has been set to collect and transmit data every five minutes to a gateway node, which talks with the processing node over the WiFi local area network. The sensor was calibrated using industry-standard procedures. When pollution levels surpass a predefined threshold value, the proposed air pollution monitoring system can provide alerts.

Another study in this field[4] is focused with the development of wireless monitoring systems that can be deployed in buildings, in which the author describes the creation of wireless monitoring systems that can be deployed in buildings. The system detects carbon dioxide, carbon monoxide, and temperature using the HVAC monitoring system.

IV. COMPONENTS

A. Optical Dust Sensor

Optical dust sensor is an air monitoring module capable of detecting fine dust particles having diameter 2.5mm , 1.0mm, 10mm and also density as well as size of the particle. The dust particles are detected through IR Emitting Diode and phototransistor connected diagonally in the device. Most common application of this sensor was found in Air purifiers , Air conditioners and PM 2.5 detector.

Table -1: Pin configuration

Sensor Pin	MCU Pin	Description
VCC	2.5V~5.0V	Power Input
GND	Ground	Ground Connection
AOUT	I/o	Analog Output
ILED	I/o	Module Driving Pin

Table -2 : Specifications

Sr No.	Parameters	Specifications
1.	Sensitivity	0.5V/(100μg/m3)
2.	Power consumption	2.5V~5.5V
3.	Operating current	20mA(max)
4.	Working temperature	-10℃~65℃

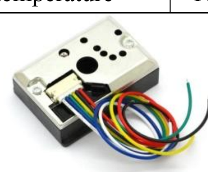

Fig -1 **:**Optical Dust Sensor

B. HEPA Filter

HEPA stands for high efficiency particulate air, which can trap 99.97 percent of 0.3 micron and 0.02 micron particles. HEPA filters have a fibrous labyrinth made up of interwoven glass fibres that are twisted and rotated in a variety of orientations. This filter has a 6 to 8 month lifespan.

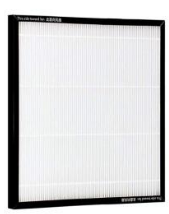

Fig -2 **:**HEPA Filter

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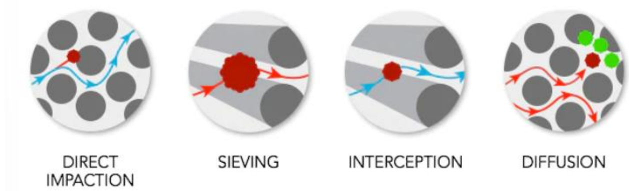
a. Working of HEPA Filter

Particles are pulled out of circulation as they pass through the web-like structure in the following ways:

- Direct Impaction: Contaminants such as dust, mould, and pollen travel in a straight line, collide with fibre, and adhere to it.
- Sieving: Larger particles are caught in the gap of an air filter carried by the air stream.
- Interception: Airflow is agile enough to reroute around fibres, while particles continue on their course and adhere to the sides of fibres owing to inertia.
- Diffusion: tiny fine particles are struck at random and cling to the fibre.



C. MQ135 Gas Sensor

This sensor is useful for detecting NH3,NOx, alcohol, Benzene, smoke, and CO2 in air quality control systems for buildings and workplaces. This sensor is made up of a plastic and stainless steel net crust with a tiny AL2O3 ceramic tube, Tin Dioxide (SnO2) sensitive layer, measuring electrode, and heater. The heater creates the ideal working environment for sensitive components. The wrapped MQ-135 has six pins, four of which are used to collect signals and the other two for heating current.

Fig -3:MQ_{135} gas Sensor

V. Methodology

The proposed system consist of two sensors that includes optical dust sensor and MQ135 gas sensor.This sensors senses any particular change in the external environment and thereby provides signal to the micontroller. Here arduino can provide only 5V at output hence rest of the supply is provided through relay module.This module is responsible for switching on or shut off the connections of high voltage devices for short duration of time that is connected to it as instructed by arduino. When the air enters in the PM 2.5 sensor through an air inlet valve , the light is continuously scattered on it which is detected by the light detector phototransistor.

The signal detected is then converted to analog voltage signal on V_o pin that is connected to analog pin of arduino. When the value of the dust in the enviornment exceeds certain value of ppm, arduino in conjunction with relay module turns on the exhaust fan and intake the air from the surrounding dusty environment.The dusty air is then projected on the HEPA filter where most of the particulate matter is trapped in the pores of the filter and remaining 0.03% of the air is reverted back through exhaust fan in the external environment.The cycle for detection of pollutants in the air is last long for 30 sec, after each 30 sec the dust sensor will reset to original value and take the new readings and operates the purifier likewise.

VI. Design of the Air Filter

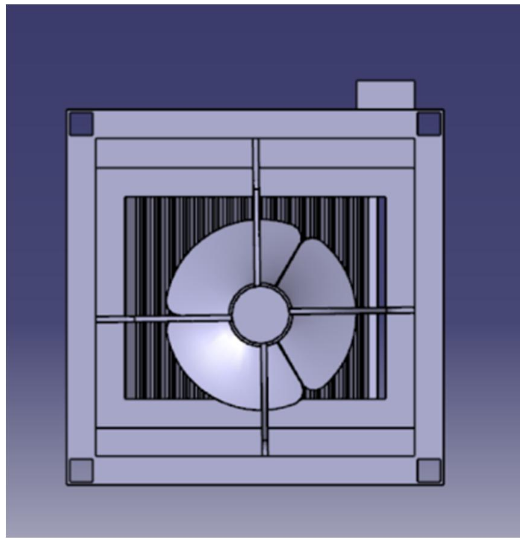


Fig 4 : Design of Air Filter

A. Calculations

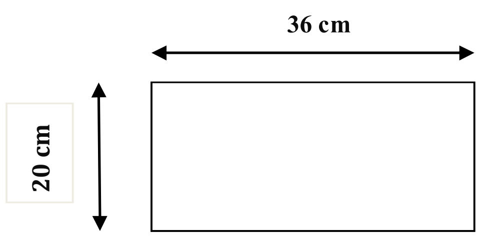


Fig 5 : Cross Section of Air Filter

Area of Filter = *Length* * *Breadth*
= 36 * 20
= 720 cm^2
Velocity (Measure from Anemometer) = 110ft/min
CFM(Cubic feet min.) = *Velocity* * *Area*
=110 * 0.775002 $feet^2$

1. Clean Air Delivery Rate(CADR):
Smoke CADR Value = *Square feet of Room/1.55*
= 10 * 15 / 1.55

2. Air Change per hour [ACH]
ACH = *CFM* * *Number of minutes in hour*
= 85.25 * 60 = 5115

3. ACH Rating
ACH Rating = *Air change in an hour/ Room Volume*
= 5115/1350
= 3.7

VII. System Architecture

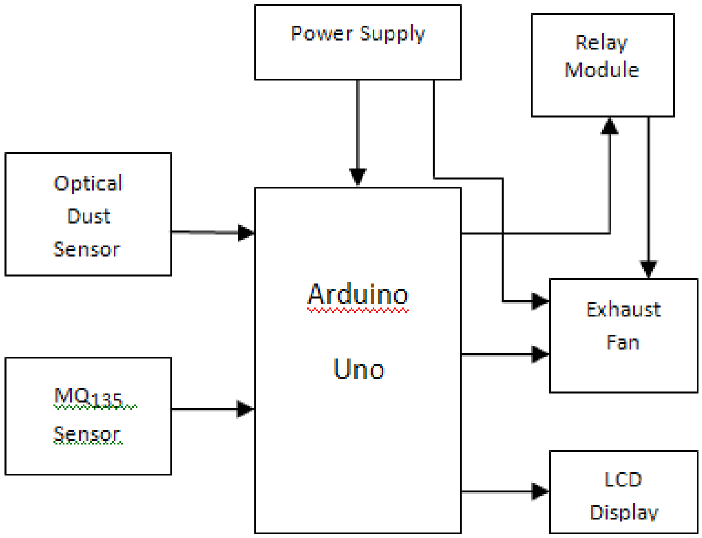
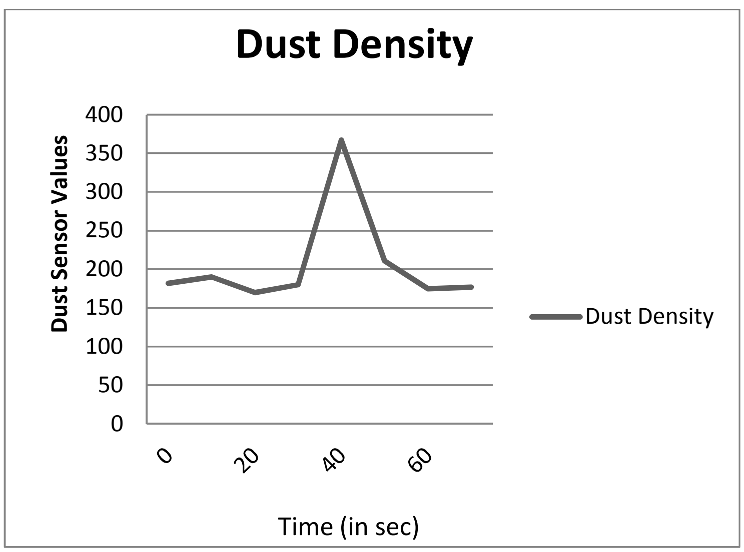


Figure 6 : Block Diagram of System

VIII. Result



- HEPA filter remove 99.97% of particle that have a size of less than 0.02 micron.
- Composite filter consisting Cold Catalyst Filter and Activated carbon require frequent replacement after 6-8 month.
- Area Cover: About 150Sq. ft. ·
- Clean Area Delivery Rate= 96.77 m^3/hr
- Air Change per Hour= 5115
- ACH Rating =3.788
- Time required to purify air to a safer lever: 10-15 min.

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