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Cost-Effective Automatic Portable Air Purifier

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Abstract: Indoor air pollution has become a severe concern on human health due to improper ventilation, pets and fine dust particles. The demand for efficient air purifiers has surged, yet many existing solutions are generally pricey and lack portability. The suggested air purifier uses modern filtration technologies, including activated carbon filters, to remove a wide range of airborne contaminants, such as dust, allergies, pet hair, and volatile organic compounds (VOCs). By adopting a tiny and lightweight design, the purifier offers outstanding portability, enabling customers to experience clean and fresh air wherever they go. The proposed air purifier possesses a distinctive design that integrates a high electric field generator and UV light source. The high electric field technique effectively accumulates and neutralizes airborne particles, including dust, pollen, mold spores, and germs. Simultaneously, the UV light component kills dangerous microbes, such as viruses and bacteria, by breaking their DNA structure, offering cleaner and healthier air. To achieve best performance and energy economy the air purifier adopts an automated operation mode. The device operates only upon the detection of motion a human being.

Keywords: Volatile Organic Compounds, Electric Field Generator, Carbon Filters

I. Introduction

In the modern era, one of the major problems affecting the majority of nations is air pollution. In India, air pollution is a significant threat to the environment. In 2019, India became home to 21 of the world's 30 most polluted cities. According to research based on 2016 statistics, 13 of the world's 20 cities with the highest yearly levels of air pollution are in India, 2 and at least 140 million people there consume air that is 10 times or more over the WHO acceptable limit. Delhi is the Indian city where air pollution is most frequently reported. Construction supplies, bioaerosols, and combustion are the primary sources of indoor air pollution. While radon, asbestos, pesticides, heavy metals, volatile organic compounds, and environmental tobacco smoke are all classified as significant indoor pollutants in developed nations, developing countries are primarily impacted by the combustible by-products of biomass fuel.

Among the many methods for reducing air pollution, "reducing pollutants in the air" is one of them. For the sake of the environment and human health, air pollution must be reduced. By passing air through various filters, pollutants in the air can be eliminated. An air purifier can be used to do this. Air purifiers may revitalize stale air, lowering the risk of health problems brought on by indoor pollutants, which can cause respiratory infections, neurological disorders, or exacerbate asthmatic symptoms. Effective air purifiers eliminate various indoor air pollutants, safeguarding our health. The purifier uses an activated carbon filter to remove dust particles and volatile organic compounds. The proposed air purifier combines two powerful purification mechanisms: a high electric field and UV light. The high electric field technology generates an intense electric field within the purifier, which effectively captures and neutralizes airborne particles, including dust, pollen, mold spores, and bacteria. This mechanism ensures that the air being circulated is free from harmful pollutants, making it safer to breathe. The purifier operates only upon detection of human motion, which helps in energy conservation.

The employment of an electric field with a UV light to destroy airborne germs is discussed in this work[1]. The combination of UV light and a high electric field creates the ideal air cleaner since the high electric field is more effective at killing bacteria. This outlines the construction of an air purification system that purifies the air by removing all dangerous germs using a UV light and an electric field. The device kills any microbes in the air using two techniques (UV and high electric field). To more effectively kill the bacteria, the high electric field was separated into three primary sections.

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The information on various gas sensors that are used to identify airborne toxins [2]. This is one of the sources we'll use to choose the air purifier's gas sensor. The provided information is on the many types of gas sensors' operating principles, the different types of air pollutants, and the sources of air pollution.

The publication includes a list of the negative health effects of indoor air pollution. Indoor air pollution, which is 10 times more than outdoor air, is the reduction of indoor air from harmful chemicals and other substances [3]. This is because enclosed rooms encourage the accumulation of possible contaminants far more than outside areas. According to statistics, indoor air pollution has a much greater negative impact on health than outdoor pollution does in developing nations.

Controlling air quality is now a crucial component of maintaining both the public's health and the long-term expansion of humankind, given the current circumstances. The most popular technique for air purification among the many available options is Particulate filtration, which uses filtering material to remove airborne particles. Membranes and fibrous materials are just a couple of the materials that have been suggested for use in air filters [4].

Previously, the main focus of attention was on personal outdoor protection, such as face masks, etc. Except for some modern commercial buildings' ventilation or central air-conditioning systems, indoor building protection has received little attention. The protective filtering equipment required by residential buildings to provide clean, hygienic air is inadequate. Porous filters and fibrous filters are the two types of filtrations that have been used the most up to this point. The latter offers the benefits of being simple for mass manufacture, affordable, and energy-efficient [5]. However, due to their comparatively large diameter of several micrometers, classic fiber filters such as spun bonded fibers, glass fibers and melt-blown fibers have a number of disadvantages, including bulkiness, a low-quality factor (QF), and a weak capacity to catch tiny particles.

II. METHODOLOGY AND MATERIALS

By incorporating essential parts into a small, lightweight container, it is possible to develop an automated, cost-effective portable indoor air purifier that uses an electric field and UV light. The purifier's required size and capacity are determined at the outset of the design process, along with a suitable housing material. To promote air circulation, a fan or blower is mounted inside the enclosure. Dust and other airborne contaminants are captured using a filter system that includes an activated carbon filter. Integrating an electric field generator and a UV light source allows the air purification procedure to be accomplished. For portability, power options such as rechargeable batteries or a power cord are offered. The air purifier's effectiveness and safety have been verified by testing.

A. *MQ2 Gas sensor*

The MQ-2 gas sensor is a low-cost, multi-purpose sensor that detects various gases, including smoke, propane, methane, and carbon monoxide. Figure 1. shows the gas sensor. It has a high sensitivity and fast response time, making it ideal for use in air quality monitoring systems. The sensor operates on a simple analog circuit and can be easily integrated into microcontroller-based projects.

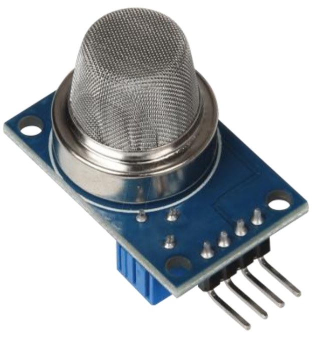

Figure 1. MQ2 gas sensor

B. PIR Motion Sensor

The PIR (Passive Infrared) motion sensor detects motion by sensing changes in infrared radiation in its field of view. Figure 2 depicts PIR sensor. It is commonly used in security systems, lighting control, and automation systems. The sensor has a wide detection range, adjustable sensitivity. It is low-cost, low-power, and easy to install, making it a popular choice for a variety of applications.

Figure 2. PIR motion sensor

C. Arduino UNO

Arduino Uno is a microcontroller board based on the ATmega328P. It has 6 analogue inputs, a 16 MHz quartz crystal, 14 digital input/output pins, a USB connection for programming, and 14 digital input/output pins. The board is open-source and easy-to-use. It is compatible with sensors, actuators, and other components, making it a versatile platform for a variety of projects. Figure 3 shows the microcontroller Arduino uno.

Figure 3. Arduino UNO

D. Fans

Suction fans are devices that generate air flow by creating a vacuum pressure. They can be used for ventilation, dust extraction, and material handling. Figure 4 shows the fans used in the purifier.

Figure 4. Fans

E. High voltage DC generator (1000 KV)

A 1000 KV high voltage DC generator produces high voltage direct current electricity. It is typically used in research, medical, and industrial applications. Figure 5 shows the HV DC generator

Figure 5. HV DC generator

F. UV Lamp

UV lamps for air purification emit UV-C radiation to kill airborne pathogens like bacteria and viruses. Figure 6 depicts the UV lamp used to kill viruses.

Figure 6. UV Lamp

G. Activated Carbon Filter

When purifying the air, volatile organic compounds (VOCs), smells, and gases are frequently removed using activated carbon filters. Figure 7 illustrates the activated carbon filter.

Figure 7. Activated Carbon Filter

H. Stainless steel mesh

To remove particulates from the air, stainless steel mesh filters use a mesh of tiny stainless steel wires. Figure 8 shows the steel mesh used in the purifier model.

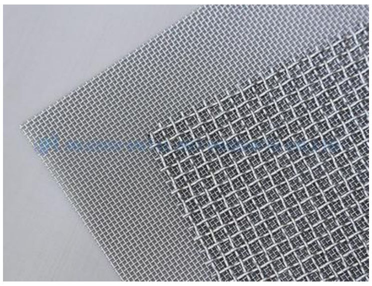

Figure 8. Stainless Steel Mesh

I. Optical Dust Sensor

Dust sensors are instruments that gauge the amount of airborne particles present in the atmosphere. They are used in air purifiers to detect levels of dust and other pollutants, allowing the purifier to adjust its cleaning performance accordingly. Figure 9 shows Dust sensor.

Figure 9. Dust Sensor

J. LCD

LCD (Liquid Crystal Display) is a type of flat-panel display used in electronic devices. Compared to more traditional display technologies, they use less energy. Figure 10 shows the LCD used to display the particulate matter present in air.

Figure 10. LCD

K. Body/framework

The enclosure of the purifier is of 40 cm length, 22 cm width and 23 cm height i.e., 40x22x23 (lxbxh). The entire enclosure is made of plywood on all he sides for the purifier. All the components are placed inside the enclosure. The enclosure looks like the Figure 11 shown below.

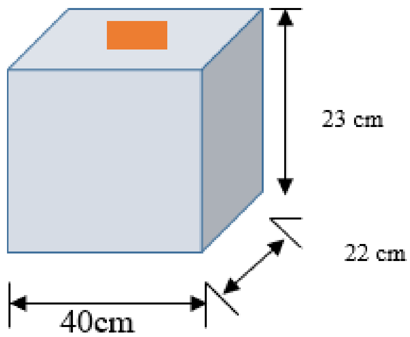

Figure 11. Framework of the model

Figure 12 shown below depicts the block diagram of the proposed model. The outer rectangle represents the outer enclosure of the Air Purifier. The enclosure contains the filters and the other major components inside it. The component which is placed at the first is Fan. The fan is placed at the beginning of the device so that it sucks the air inside the device. A motion sensor is placed beside the fan, on the same surface of the device. The motion sensor detects the motion and send a signal to the microcontroller. The microcontroller used in this device is Arduino UNO. Arduino UNO receives the signal from the motion sensor and turns the Air Purifier on. When there is no motion detected continuously for a certain period, the motion sensor sends another signal to Arduino UNO which turns off the Air Purifier. Two sensors, a dust sensor and a MQ2 gas sensor, are installed to measure the amount of pollutants in the air. The MQ2 gas sensor detects gases like methane and carbon monoxide in the air, while the dust sensor counts the number of dust particles in the air. The measured numbers are sent as signals to Arduino UNO. The microcontroller sends this data to the LCD. The values are displayed on the LCD. After entering the purifier, the air is now cleansed by passing through various filters. Activated carbon filter is the top filter layer. By trapping dust particles on its surface, the activated carbon filter lowers the amount of contaminants in the air. High electric field filters make up the second layer. The germs in the air are killed by the strong electric field created by applying high voltage to the stainless-steel mesh. UV Lamps make up the third filter layer. The viruses that are in the air are eliminated by the UV lamp. The fan then blows the cleaned air outside of the purifier.

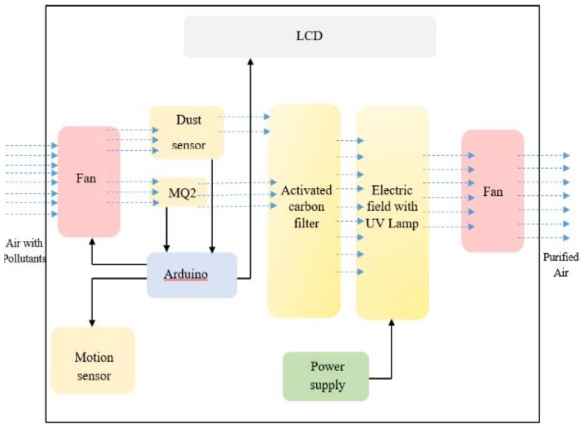

Figure 12. Block diagram

III. Results And Discussions

A. Software Requirement

The purifier can't run without programming in both software and hardware. Each component needs to be given a purpose or a part to play in a different situation. The components interact and carry out the necessary task in accordance with the circumstance. Writing a productive program to carry out the task will enable this. The microcontroller and sensors used by the purifier must all be programmed separately and made to communicate with one another.

The user's computer must have an Arduino IDE installed in order to dump the code into the Arduino. For sensors to operate and activate on the Arduino, code needs to be created. The code is written, then copied into the Arduino and connected to the power source. The programming language used to create this microcontroller's code is C.

B. Calculation of purification time

Usually, capacity of air purifier is measured in terms of CFM (Cubic Feet per minute).

1 CFM= 1.7 m^3/hour

1 m^3/hour= 0.589 CFM

Air flow through the fan which we have used in our project is 150 CFM, that is, 150 cubic feet volume of air is purified by the fan in one minute.

The amount of air that has to be cleaned and the size of the space will determine how long it will take the purifier to do it. The amount of time needed to purify the air in a room with a volume of 1800 cubic feet is,

$$\frac{1800\ CF}{150\ CFM} = 12\ minutes$$

C. Testing and results

The prototype model is tested for two different sealed space of dimension of 12 X 6.5 X 9 feet, dimension of 14 X 10 X 10 inches, to observe the collected pollutants. The door is made to open for a duration of 0,3, 10 & 12 minutes respectively. The readings of the dust and gas sensors are displayed is observed on the LCD and is tabulated in Table 1, Table 2 respectively. The major observed pollutants are fine dust particles, gas molecules liberated by the vehicle.

Table 1. Measured data of pollutants for dimension of 12 X 6.5 X 9 feet

Time	MQ2 Sensor	Dust Sensor
0^{th} minute	414	0.240
3^{rd} minute	262	0.230

10th minute	209	0.200
12th minute	178	0.190

Table 2. Measured data of pollutants for dimension of 14 X 10 X 10 inches

Time	MQ2 Sensor	Dust Sensor
0th minute	170	0.250
3rd minute	220	0.520
10th minute	195	0.440
12th minute	178	0.240

The prototype is turned on for purification and data is tabulated in Table 3. The suction fan pulls the contaminated air inside the purifier. The air passes through the carbon filter where all the dust particles were adsorbed on it. The air passes through a stainless steel mesh for which electric field is created. The strong electric field is created to destroy the microorganism present in the air. The UV light then kills the viruses and the purified air liberates from the purifier through the exhaust fan. The readings can be seen in the LCD. Figure 13 depicts the front view of the model and Figure 14 depicts the back view of the purifier model. Figure 15 illustrates the circuit inside the model.

Table 3. Measured data of pollutants after purification

Time		MQ2 Sensor	Dust Sensor
1 minute	Case 1	300	0.120
3 minutes	Case 1	Does not detect any gas	-
1 minute	Case 2	150	0.110
2 minutes	Case 2	Does not detect any gas	-

Figure 13. Front view

Figure 14. Back view

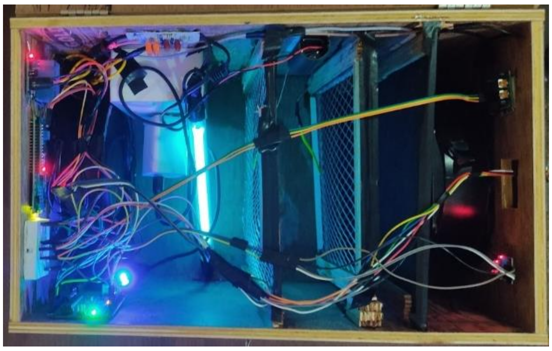

Figure 15. Circuit inside the model

IV. CONCLUSION

To make an informed decision, users should consider their specific needs, budget, maintenance preferences, and noise tolerance. It is advisable to research and compare different models, paying attention to factors such as filter lifespan, energy efficiency ratings, noise levels, and maintenance costs. By selecting the most suitable air purifier, users can enjoy the advantages of cleaner and healthier indoor air while mitigating the associated drawbacks. These devices are an investment in creating a more comfortable and breathable living environment. The proposed cost - effective automatic portable indoor air purifier is a device to keep indoor premises and offices clean. The electric field technology and UV light technology helps in killing minute pollutants like microorganisms and viruses. This creates a safer environment for the users. The Automation of the purifier helps in conserving the energy and makes the purifier a smart device that runs in the presence of a human. The portability of the purifier has made it easy to carry and place it accordingly. The proposed system is tested for two different dimensions of indoor area and measured the acquired dust particles with the help of sensors. The same is tested with the technology of UV and electric field and obtained a promising result in removing the pollutants. In conclusion, a cost-effective portable indoor air purifier with high electric field and UV light provides an affordable and efficient solution to improve indoor air quality by effectively eliminating pollutants and microorganisms, while also offering portability, convenience, and energy efficiency.

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