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SOLAR POWERED AIR QUALITY MONITOR AND AIR PURIFIER

[1]Mr.Kishore Ganesh .V , [2]Dr. S. Sakthivel, [3] Mr. K. Edison prabhu
[1,2,3] Department of EEE, Nehru Institute of Engineering and Technology, Tamilnadu, India

Abstract— The world has been shaken by rising pollution levels due to air pollution. We need to control the pollution levels under safe and standard levels. Using air purifiers is the most effective method of reducing air pollution. Here we design an outdoor purifier powered by a solar panel, it does not require any other supply, so it is energy independent. Air purifier's concept is known for years but not fully explored, so here we are designing an air purifier that removes PM10 and PM2.5 pollutants as well as harmful gases uses a exhuast fan to draw air from the base duct of the purifier through a layer of HEPA and Carbon filters. The purifier employs two stage purification, with the first layer being HEPA second being an Active Carbon filter. The combination of these two filters results in dual filtration by sucking large amounts of air and purifying it of dust particles using centrifugal air force.

I. INTRODUCTION

As we know, air pollution levels in cities are very high. Most of the pollution comes as by-product from vehicles, produced waste gases from industries and dust from construction sites, these are in the form of particulate matter which are like methane, carbon dioxide, dust etc. These create a lot of health issues like asthma, decreased lung functions, pregnancy failing etc.

Indoor air quality (IAQ) is the air quality inside and outside of buildings and structures. IAQ has been shown to have an impact on the health, comfort, and well-being of building occupants. Government agencies use an air quality index (AQI) to communicate to the public how polluted the air is now or how polluted it is expected to become. As the AQI rises, so do the risks to public health. Each country has its own air quality index, which corresponds to different national air quality standards.

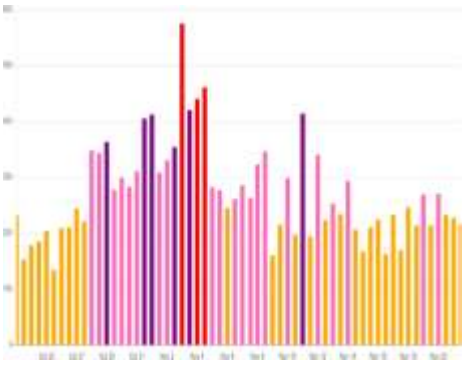

Figure 1 : Concentration graph of PM 2.5

PM 2.5	AIR QUALITY INDEX	PM2.5 HEALTH EFFECTS
0-13.0	Good [0-50]	Little to no risk
13.1-36.4	Moderate [51-100]	Usually sensitive individuals may experience respiratory symptoms
36.5-56.4	Unhealthy for sensitivity group [101-150]	Increasing likelihood of respiratory symptoms in sensitive individuals, aggravation of heart or lung disease
56.5-151.4	Unhealthy [151-200]	Premature mortality in persons with cardiopulmonary disease and elderly
151.5-251.4	Very unhealthy [201-300]	Significant aggravation of heart or lung disease & Premature mortality in persons with cardiopulmonary disease and elderly ; significant increase in respiratory effects in general population
251.5-600.4	Hazardous [301-500]	Very serious aggravation of heart or lung disease and Premature mortality in persons with cardiopulmonary disease and elderly ; serious risk of respiratory effects in general population

Table 1 : Air Quality Index

The introduction of the solar-powered air purifier with an air quality monitor highlights the need for addressing air pollution and the growing demandfor sustainable energy solutions. It provides an overview of the system and its key features.

Air pollution has become a significant global concern, with adverse effects on human health and the environment. Indoor air pollution, in particular, poses a significant risk as people spend a significant

Mr. Kishore Ganesh .V , UG Scholar , Department of Electrical and Electronics Engineering , Nehru Institute of Engineering and Technology Coimbatore-641105
Dr. S. Sakthivel, Professor , Department of Electrical and Electronics Engineering , Nehru Institute of Engineering and Technology Coimbatore-641105
Mr. K. Edison prabhu, Assistant Professor , Department of Electrical and Electronics Engineering , Nehru Institute of Engineering and Technology Coimbatore-641105

amount of time indoors. Traditional air purifiers rely on electricity from the grid, contributing to energy consumption and greenhouse gas emissions.

To address these challenges, the solar-powered air purifier with an air quality monitor is introduced. This system harnesses solar energy as a renewable power source, reducing its environmental impact and promoting sustainability. Solar power offers a clean and abundant energy alternative, making it an ideal choice for powering air purification systems.

The solar-powered air purifier employs advanced purification technologies to effectively remove pollutants from the air. These technologies may include high-efficiency particulate air (HEPA) filters, activated carbon filters, and photocatalytic oxidation, among others. The combination of these technologies ensures the purification of the air from harmful particles, allergens, and pollutants, leading to cleaner and healthier indoor environments.

In summary, the solar-powered air purifier with an air quality monitor offers a sustainable and efficient solution for combating air pollution. By utilizing solar energy and incorporating real-time air quality monitoring, this system contributes to environmental conservation and promotes healthier living conditions. The subsequent sections of this study will delve into the system's design, working principles, and experimental results, demonstrating its effectiveness in improving indoor air quality.

Our solar air purifier has a suction fan that draws air from the bottom of the purifier through a layer of HEPA and Carbon filters to remove PM10, PM2.5, and gases. A battery that is also used for purifier night uses in daylight will be charged by solar panel voltage. As a result, we intend to create a solar-powered purifier that uses biodegradable filters and runs on solar energy. Our goal is to create low-cost, high- efficiency air.

As we know that air pollution occurs due to many reasons just like burning of solid fuels, crop waste, charcoal and building demonstrates so to prevent this polluted air many types of air filter are designed but none of them did not succeed. Some have efficiency problems, some have backup power problems and whereassome have desirable filtration problems.

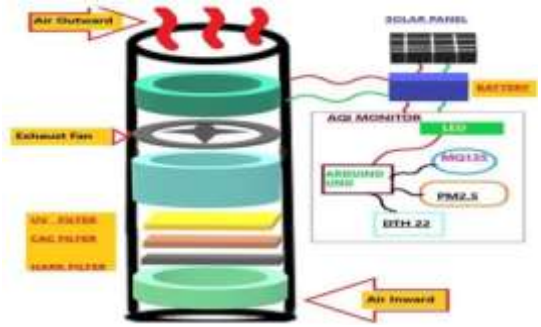

Figure 2 : SYSTEM METHODOLOGY

II. EMBEDDED INTRODUCTION

An embedded system is a special-purpose computer system, which is completely encapsulated by the device it controls. An embedded system has specific requirements and performs pre-defined tasks, unlike a general-purpose personal computer. An embedded system is a programmed hardware device. A programmable hardware chip is the 'raw material' and it is programmed with particular applications. This is to be understood in comparison to older systems with fully functional hardware or systems with general - purpose hardware and externally loaded software. Embedded systems are a combination of hardware and software which facilitates mass production and variety of application. A combination of computer hardware and software, and perhaps additional mechanical or other parts, designed to perform a dedicated function.

EMBEDDED SYSTEM is a combination of **SOFTWARE** and

1)HARDWARE.

An Embedded system is a system that has a computing device embedded into it. These are the controllers, processors, arrays or other hardware using dedicated (embedded) logic or programming (code) called "firmware" or a "microkernel.Embedded systems are designed around a µC which integrates Memory & Peripherals.

2)What are they?

A special purpose computer built into a larger device

- ***'Special-purpose'***

Embedded systems have a (more or less) well-defined purpose Contrast with general purpose computers (PCs etc.)

- ***'Built into a larger device'***

Embedded systems are (usually) part of a larger device, augmenting itscapabilities.

3) WHY EMBEDDED SYSTEMS

It is **EMBEDDED** because the Micro Controller is 'inside' some othersystem.

For Example, a Micro Controller is '**EMBEDDED**' into your TV, car, or appliance The consumer need not think about how to make it perform or process.

Avoids lots of Electronics Components

- Built in rich Features
- Reduces the cost, space
- Less Down Time for Maintenance
- Probability of Failure is reduced
- Easy interface with Computers

A. CHARACTERISTICS OF AN EMBEDDED SYSTEM

1. Sophisticated functionality
2. Real-Time Operation
3. Low Manufacturing Cost
4. Low Power Consumption
5. Eliminates Necessity of Complex Circuitry
6. Smarter Products
7. Smaller Size
8. User Friendly
9. State of the Art Technology

B. FOUR GENERAL EMBEDDED SYSTEMS TYPES

1)GENERAL COMPUTING:

- Applications similar to desktop computing, but in an embedded package
- Video games, set- top boxes, wearable computers, automatic tellers

2)CONTROL SYSTEMS:

- Closed- loop feedback control of real- time system

Vehicle engines, chemical processes, nuclear power, flight control

3)SIGNAL PROCESSING:

- Computations involving large data streams
- Radar, Sonar, video compression

4)COMMUNICATION & NETWORKING:

- Switching and information transmission
- Telephone system, Internet

C. FEATURES OF AN EMBEDDED SYSTEM

1) REAL-TIME OPERATION:

- Reactive: computations must occur in response to external events
- Correctness is partially a function of time

2) SMALL SIZE, LOW WEIGHT

- Hand- held electronics and Transportation applications -- weight costsmoney

3)LOW POWER

- Battery power for 8+ hours (laptops often last only 2 hours)

4)HARSH ENVIRONMENT

Heat, vibration, shock, power fluctuations, RF interference, lightning,corrosion.

III. EXISTING SYSTEM

The existing system of the solar-powered air purifier with an air quality monitor refers to the currently available technologies and products in this field. This section provides an overview of the existing systems and highlights their limitations and shortcomings.

In recent years, there has been an increasing demand for air purifiers that utilize renewable energy sources. Several manufacturers have introduced solar- powered air purifiers with integrated air quality monitors to meet this demand. These systems typically consist of the following components:

1)Solar Panels:

Solar panels are used to capture sunlight and convert it into electrical energy. They are designed

to maximize solar energy absorption and generate power to operate the air purifier.

2)Air Quality Monitor:

An integrated air quality monitor continuously measures and analyzes the concentration of various air pollutants. It typically includes sensors for detecting particulate matter (PM), volatile organic compounds (VOCs), carbon dioxide (CO2), and other harmful gases.

3)Air Purification Technologies:

Existing systems employ various air purification technologies to remove pollutants from the air. Common technologies include HEPA filters, activated carbon filters, ionizers, and UV germicidal lamps. These technologies are responsible for capturing and eliminating particles, allergens, odors, and harmful gases.

Despite the advancements in solar-powered air purifiers with air quality monitors, there are some limitations.

A. LIMITATIONS

1)Limited Power Generation:

Solar panels have limited power generation capabilities, especially under low light conditions or in areas with limited sunlight. This can affect the efficiency and continuous operation of the air purifier.

2)Size and Portability:

Some solar-powered air purifiers can be bulky and not easily portable, which limits their flexibility in terms of placement and usage in different indoor environments.

3)Maintenance and Filter Replacement:

Like conventional air purifiers, solar-powered systems require regular maintenance, including filter replacements, to ensure optimal performance. Users need to be aware of these maintenance requirements and carry them out accordingly.

4)Cost:

Solar-powered air purifiers can be relatively expensive compared to traditional air purifiers. The cost of solar panels, specialized components, and advanced air purification technologies contribute to the overall price of the system.

In conclusion, the existing systems of solar-powered air purifiers with air quality monitors have made significant strides in utilizing renewable energy and providing real-time air quality monitoring. However, improvements are needed to address limitations such as limited power generation, size, maintenance requirements, and cost. These challenges provide opportunities for further research and development in the field to enhance the efficiency, effectiveness, and affordability of solar-powered air purification systems.

IV. PROPOSED SYSTEM

The proposed system of the solar-powered air purifier with an air qualitymonitor incorporates the following features:

1)Solar Power Generation:

The system utilizes efficient solar panels to generate electrical power from sunlight. These solar panels are designed to capture maximum solar energy, ensuring a sustainable and renewable power source for the air purifier.

2)Air Quality Monitoring:

An integrated air quality monitor is equipped with an MQ135 sensor to measure the concentration of air pollutants. The MQ135 sensor can detect various gases, including volatile organic compounds (VOCs), carbon monoxide (CO), ammonia (NH3), and nitrogen oxides (NOx). The air quality data collected by the sensor provides real-time information about the pollution levels in the surrounding environment.

3)LCD Display:

The system features an LCD display that shows the measured air quality parameters, such as pollutant concentrations and air quality index (AQI). The display provides clear and easy-to-read information for users to monitor theair quality in real-time.

4)Inlet and Outlet Air Monitoring:

The system incorporates sensors to measure the air quality at both the inlet and outlet of the air purifier.

By comparing the pollutant levels before and after purification, users can assess the effectiveness ofthe air purifier in removing contaminants from the air.

5)Purified Air Calculation:

The system calculates the level of purified air based on the difference in pollutant concentrations between the inlet and outlet air. This calculation provides users with quantitative information about the air purificationefficiency of the system.

By combining solar power generation, air quality monitoring with the MQ135 sensor, LCD display, and inlet/outlet air monitoring, the proposed system offers a comprehensive solution for solar-powered air purification. Users can easily assess the air quality, monitor the purification process, and evaluate the system's performance in removing pollutants from the air.

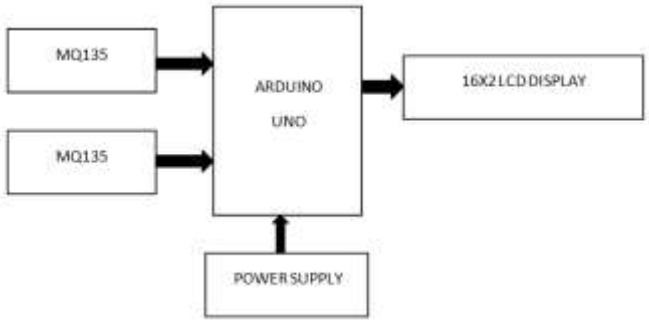

Figure 3 : Block Diagram Of Proposed System

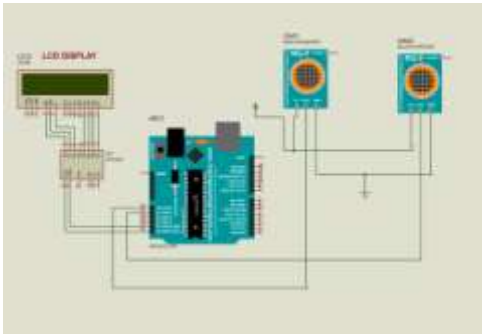

Figure 4 : Circuit Diagram

ADVANTAGES

- ✓ Heavy Duty Purifiers
- ✓ Automatic Operation
- ✓ Fast Purification
- ✓ Easy to Clean Removable Filters
- ✓ No External Power Supply Needed

V. HARDWARE

LIST OF HARDWARE

- ➢ Arduino Uno
- ➢ Solar Panel
- ➢ MQ135
- ➢ LCD Display
- ➢ Power switch

1) ARDUINO

A. INTRODUCTION TO ARDUINO

Arduino interface boards provide the engineers, artists, designers, hobbyists and anyone who tinker with technology with a low-cost, easy- to-use technology to create their creative, interactive objects, useful projects etc., A whole new breed of projects can now be built that can be controlled from a computer.

Arduino is a open source electronics prototyping platform based on flexible, Easy - to-use hardware and Software. It's intended for artists, designers, hobbyists, and anyone interested in Creating interactive objects or environments.

It's an open-source physical computing platform based on a microcontroller board, and a development environment for writing software for the board. In simple words, Arduino is a small microcontroller board with a USBplug to connect to your computer and a number of connection sockets that can bewired up to external electronics ,such as motors, relays, light sensors, laser diodes, loudspeakers, microphones, etc., They can either be powered through the USB connection from the computer or from a 9V battery. They can be controlled fromthe computer or programmed by the computer and then disconnected and allowedto work independently.

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor,a finger on a button, or a Twitter message - and turn it into an output - activatinga motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. Todo so you use the Arduino programming language (based on

Wiring), and the Arduino Software (IDE), based on Processing.

Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers - students, hobbyists, artists, programmers, and professionals - has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novicesand experts alike.

Arduino was born at the Ivrea Interaction Design Institute as an easy tool for fastprototyping, aimed at students without a background in electronics and programming. As soon as it reached a wider community, the Arduino board started changing to adapt to new needs and challenges, differentiating its offer from simple 8-bit boards to products for IOT applications, wearable, 3D printing, and embedded environments. All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs. The software, too, is open-source, and it is growing through the contributions of users worldwide.

B. HISTORY OF ARDUINO

While teaching a physical computing class at the Interaction Design Institute Ivrea in 2005, Massimo Banzi's students were unwilling to spend the 76euros for the BASIC Stamp microcontrollers commonly used in such applications. Banzi and his collegues looked for alternatives, finally settling on the wiring platform developed by one of Banzi's students.

In his own words: we started to figure out how could we make the whole platform even simpler, even cheaper, even easier to use. And then we started to essentiallyre implement the whole thing as an open source project.

Once they had a prototype, a student wrote the software that would allow wiring programs to reunion the new platform. Upon seeing the project, visiting professor Casey Reas suggested that there might be wider applications than just design schools for the new product. The prototype was redesigned for mass production and a test run of 200 boards was made. Orders began coming in from other design schools and the students looking for Arduinos

The Arduino project was born and Massimo Banzi and David Cuartielles became its founders. ARDUINO is an Italian word, meaning STRONG FRIEND. The English version of the name is Hardwin. As of May2011, more than 300,000 Arduino units are in the wild.

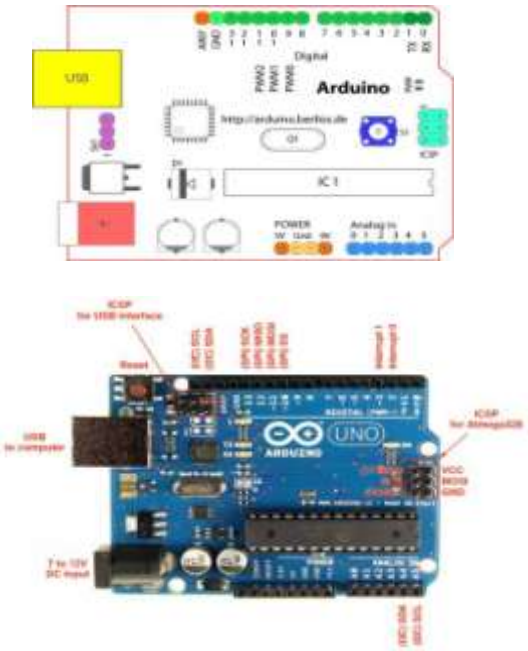

Figure 5 : ARDUINO Pin Diagram

C. FEATURES:

- ***High-performance, Low-power AVR®***

- 8-bit Microcontroller

- ***Advanced RISC Architecture***

– 130 Powerful Instructions – Most Single-clock Cycle Execution

– 32 x 8 General Purpose Working Registers

– Fully Static Operation

– Up to 16 MIPS Throughput at 16 MHz

– On-chip 2-cycle Multiplier

- ***High Endurance Non-volatile Memory segments***

– 8K Bytes of In-System Self-programmable Flash program memory

– 512 Bytes EEPROM

– 1K Byte Internal SRAM

– Write/Erase Cycles: 10,000 Flash/100,000

EEPROM

– Data retention: 20 years at 85°C/100 years at 25°C (1)

– Optional Boot Code Section with Independent Lock Bits

- ***In-System Programming by On-chip Boot Program***

– True Read-While-Write Operation

– Programming Lock for Software Security

- ***Peripheral Features***

– Two 8-bit Timer/Counters with Separate Prescaler, one compare

- ***Six Channels 10-bit Accuracy***

– Byte-oriented Two-wire Serial Interface

– Programmable Serial USART

– Master/Slave SPI Serial Interface

– Programmable Watchdog Timer with Separate On-chip

- ***Oscillator***

– On-chip Analog Comparator

- ***Special Microcontroller Features***

Power-on Reset and Programmable Brown-out Detection

– Internal Calibrated RC Oscillator

– External and Internal Interrupt Sources

– Five Sleep Modes: Idle, ADC Noise Reduction, Power-save

- ***I/O and Packages***

– 23 Programmable I/O Lines

– 28-lead PDIP, 32-lead TQFP, and 32-pad QFN/MLF

- ***Operating Voltages***

– 2.7 - 5.5V (ATmega8L)

– 4.5 - 5.5V (ATmega8)

- ***Power Consumption at 4 Mhz, 3V, 25°C***

– Active: 3.6 mA

– Idle Mode: 1.0 mA

– Power-down Mode: 0.5 µA

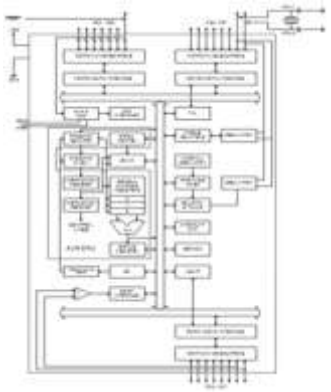

Figure 6 : Arduino Architecture Diagram

D. PIN CONFIGURATIONS

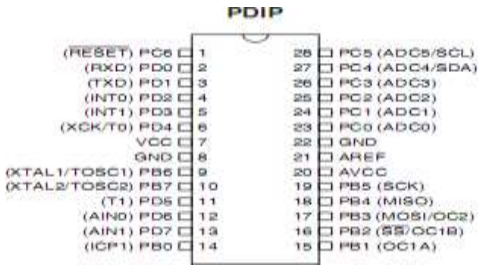

Figure 7 : Pin Configuration

The ATmega8 is a low-power CMOS 8-bit microcontroller based on the AVR RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega8 achieves throughputs approaching 1 MIPS per MHz, allowing the system designed to optimize power consumption versus processing speed.

Pin Descriptions:

VCC :-Digital supply voltage.

GND:- Ground.

Port B(PC7..PB0) :- is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active,even if the clock is not running.

Port C (PC5..PC0) :- Port C is an 7-bit bi-directional I/O port with internal pull- up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source

current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port D (PD7..PD0) :- Port D is an 8-bit bi-directional I/O port with internal pull- up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active,even if the clock is not running.

RESET (Reset input):- A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. The Shorter pulses are not guaranteed to generate a reset.

AVCC:- AVCC is the supply voltage pin for the A/D Converter, Port C (3..0), and ADC (7..6). It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter.

AREF:- AREF is the analog reference pin for the A/D Converter.These pins are powered from the analog supply and serve as 10-bit ADC channels.

Basic Function:- The main function of the CPU core is to ensure correct program execution. The CPU must therefore be able to access memories,

perform calculations, control peripherals, and handle interrupts.

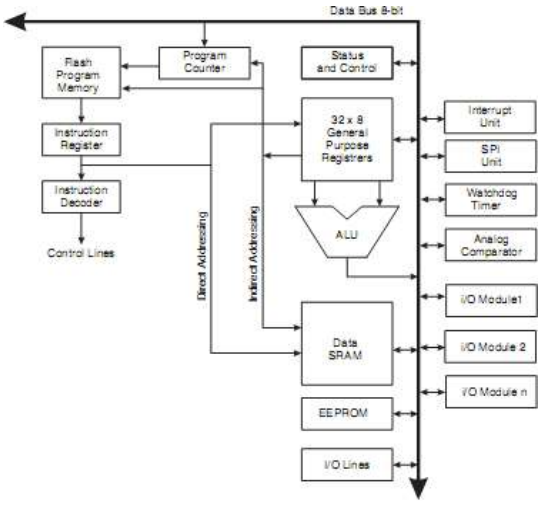

Figure 8 : Interfacing Of Data Bus With Different Units

E. LEAD ACID BATTERIES

Lead acid batteries are the most common large-capacity rechargeable batteries. They are very popular because they are dependable and inexpensive on a cost- per-watt base. There are few other batteries that deliver bulk power as cheaply as lead acid, and this makes the battery cost-effective for automobiles, electrical vehicles, forklifts, marine and uninterruptible power supplies (UPS).

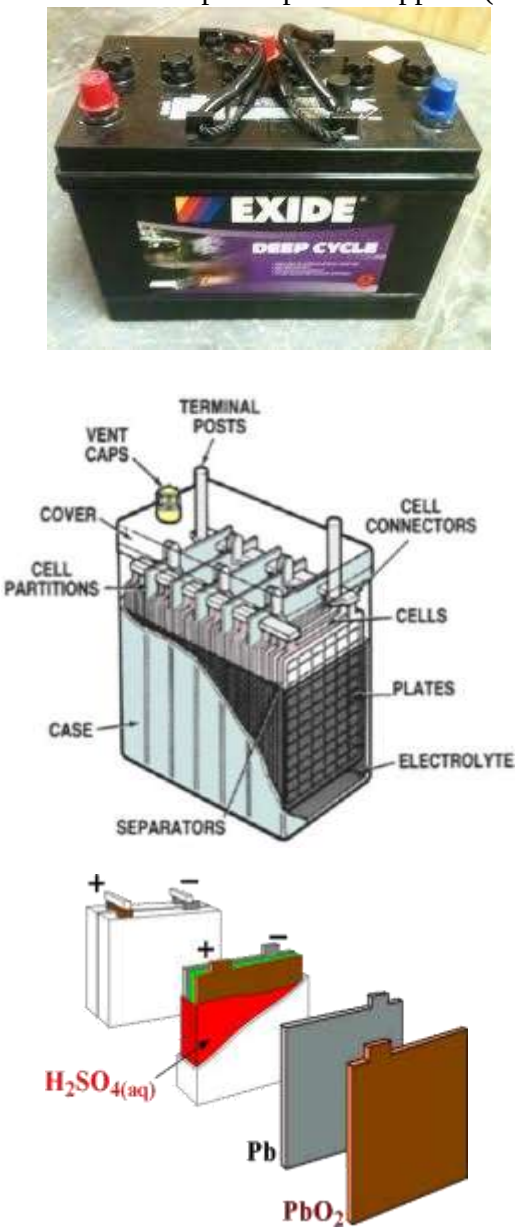

Figure 9 : Battery

Lead acid batteries are built with a number of individual cells containing layers of lead alloy

plates immersed in an electrolyte solution, typically made of 35% sulphuric acid (H2SO4) and 65% water. Pure lead (Pb) is too soft and would not support itself, so small quantities of other metals are added to get the mechanical strength and improve electrical properties. The most common additives are antimony (Sb), calcium (Ca), tin (Sn) and selenium (Se). When the sulphuric acid comes into contact with the lead plate, a chemical reaction is occurring and energy is produced.

Lead acid batteries are heavy and less durable than nickel (Ni) and lithium (Li) based systems when deep cycled or discharged (using most of their capacity). Lead acid batteries have a moderate life span and the charge retention is best among rechargeable batteries. The lead acid battery works well at cold temperatures and is superior to lithium-ion when operatig in sub-zero conditions. Lead acid batteries can be divided into two main classes: vented lead acid batteries (spillable) and valve regulated lead acid (VRLA) batteries (sealed or non-spillable).zTypical vented lead acid battery schematic

- Lead acid batteries are usually filled with an electrolyte solution containing sulphuric acid. This is a very corrosive chemical (pH<2) which can permanently damage the eyes and produce serious chemical burns to the skin. Sulphuric acid is also poisonous, if swallowed. The lead alloys foundin batteries are also harmful to humans and can also seriously damage theenvironment.
- Wear the proper personal protective equipment (PPE), specifically splash- proof goggles, acid-resistant lab coat or apron, safety shoes and rubber gloves. A face shield must also be worn when refilling batteries with electrolytes.
- Know where the emergency showers and emergency eyewash stations are located; they must be located near lead acid battery storage and charging areas.
- Slowly pour concentrated acid into water; do not add water to acid. (warning: electrolyte will become hot; do not close battery vents until electrolyte has cooled down)
- Use non-metallic containers and funnels.
- Ensure neutralizers (e.g. baking soda) are available for immediate use.

Use extreme care to avoid spilling or splashing the sulphuric acid solution.

Table 3 : Electrolyte Spill

Health Risks (WHMIS 2015)	
color	clear
odor	sharp, pungent
pH	1 to 2
Boiling point	95-115°C
LC50 (rat)	375 mg/m^3
LD50 (oral, rat)	2140 mg/kg

In the event of a minor electrolyte spill, consult the appropriate Safety Data Sheet (SDS) for electrolyte spill containment, clean-up and disposal details. Always ensure to wear adequate protective clothing (goggles, closed shoes and gloves) during clean-up of spills.

In case of a small electrolyte spilled, you should:

- Contain the spill with absorbents such as universal pads, hazmat pads, sand, earth orvermiculite.
- Remove the absorbents once it has soaked up the acid/electrolyte.
- Clean up spilled acid safely with an acid neutralizer and then withlarge volumes of water torinse the area.

In the event of a large acid electrolyte spill:

1. Advise and warn co-workers.
2. Evacuate the area immediately.
3. Restrict the access to the area.

1)RECTIFIER:

The Rectifier circuit is used to convert the AC voltage into its correspondingDC voltage.

Rectifier having three types,

- Half wave rectifier.
- Full wave rectifier
- Bridge rectifier

The most important and simple device used in Rectifier circuit is the diode. This project used to bridge rectifier.A bridge rectifier makes use of four diodes in a bridge arrangement to achieve full-wave

rectification. This is a widely used configuration, both with individual diodes wired as shown and with single component bridges where the diode bridge is wired internally.

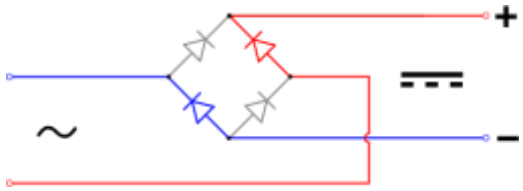

Figure 10 : Circuit diagram of bridge rectifier

The simple function of the diode is to conduct when forward biased and not to conduct in reverse bias. The Forward Bias is achieved by connecting the diode's positive with positive of the battery and negative with battery's negative. The efficient circuit used is the Full wave Bridge rectifier circuit. The output voltageof the rectifier is in rippled form, the ripples from the obtained DC voltage are removed using other circuits available. The circuit used for removing the ripplesis called Filter circuit.

The simple capacitor filter is the most basic type of power supply filter. The application of the simple capacitor filter is very limited. It is sometimes used on extremely high-voltage, low-current power supplies for cathode-ray and similar electron tubes, which require very little load current from the supply. The capacitor filter is also used where the power-supply ripple frequency is not critical; this frequency can be relatively high. The capacitor (C1) shown in figure 4-15 is a simple filter connected across the output of the rectifier in parallel withthe load.

Capacitors are used as filter. The ripples from the DC voltage are removed and pure DC voltage is obtained. And also these capacitors are used to reduce the harmonics of the input voltage. The primary action performed by capacitor is charging and discharging. It charges in positive half cycle of the AC voltage andit will discharge in negative half cycle. Here we used 1000µF capacitor. So it allows only AC voltage and does not allow the DC voltage. This filter is fixed before the regulator. Thus the output is free from ripples. The simple capacitor filter is the most basic type of power supply filter. The application of the simple capacitor filter is very limited. It is sometimes used on extremely high-voltage, low-current power supplies for cathode-ray and similar electron tubes, which require very little load current from the supply. The capacitor filter is also used where the power-supply ripple frequency is not critical; this frequency can be relatively high. The capacitor (C1) shown in figure 4-15 is a simple filter connected across the output of the rectifier in parallel with the load.

2)REGULATOR:

Regulator regulates the output voltage to be always constant. Regulator havingtwo types.

- Positive regulator (78XX)
- Negative regulator (79XX)

The output voltage is maintained irrespective of the fluctuations in the input ACvoltage. As and then the AC voltage changes, the DC voltage also changes. Thus to avoid this Regulators are used. Also when the internal resistance of the powersupply is greater than 30 ohms, the output gets affected. Thus this can be successfully reduced here. The regulators are mainly classified for low voltage and for high voltage. Here we used 7805 positive regulator. It reduces the 12V dcvoltage to 5V dc.

The Filter circuit is often fixed after the Regulator circuit. Capacitor is most often used as filter. The principle of the capacitor is to charge and discharge. It charges during the positive half cycle of the AC voltage and discharges during the negative half cycle. So it allows only AC voltage and does not allow the DC voltage. This filter is fixed after the Regulator circuit to filter any of the possibly found ripples in the output received finally. Here we used 0.1µF capacitor. The output at this stage is 5V and is given to the Microcontroller In the power supply circuit two regulators are used. 7805 regulator is used to produce positive 5V dc. Microcontroller and sensors are operated at 5V dc voltage. The output of the 7805 regulator is connected to Arduino Nano microcontroller.

3) LCD DISPLAY

The most commonly used Character based LCDs are based on Hitachi's HD44780 controller or other which are compatible with HD44580. In this tutorial, we will discuss about character based LCDs, their interfacing with various microcontrollers, various interfaces (8-bit/4-bit),

programming, special stuff and tricks you can do with these simple looking LCDs which can give a new look to your application.

PIN DESCRIPTION

The most commonly used LCDs found in the market today are 1 Line, 2 Line or 4 Line LCDs which have only 1 controller and support at most of 80 characters, whereas LCDs supporting more than 80 characters make use of 2 HD44780 controllers.

Most LCDs with 1 controller has 14 Pins and LCDs with 2 controller has 16 Pins (two pins are extra in both for back-light LED connections). Pin description is shown in the table below.

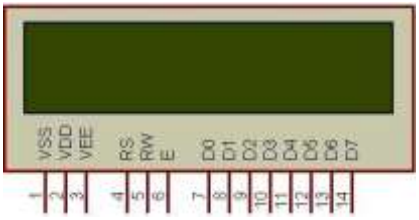

Figure 11 : LCD Pin diagram (16*2)

Table 4 : LCD Pin Description

Pin No.	Name	Description
Pin no. 1	**VSS**	Power supply (GND)
Pin no. 2	**VCC**	Power supply (+5V)
Pin no. 3	**VEE**	Contrast adjust
Pin no. 4	**RS**	0 = Instruction input 1 = Data input
Pin no. 5	**R/W**	0 = Write to LCD module 1 = Read from LCD module
Pin no. 6	**EN**	Enable signal
Pin no. 7	**D0**	Data bus line 0 (LSB)
Pin no. 8	**D1**	Data bus line 1
Pin no. 9	**D2**	Data bus line 2
Pin no. 10	**D3**	Data bus line 3
Pin no. 11	**D4**	Data bus line 4
Pin no. 12	**D5**	Data bus line 5
Pin no. 13	**D6**	Data bus line 6
Pin no. 14	**D7**	Data bus line 7 (MSB)

Table 5 : Character LCD pins with 1 Controller

Pin No.	Name	Description
Pin no. 1	**D7**	Data bus line 7 (MSB)
Pin no. 2	**D6**	Data bus line 6
Pin no. 3	**D5**	Data bus line 5
Pin no. 4	**D4**	Data bus line 4
Pin no. 5	**D3**	Data bus line 3

Pin no. 6	**D2**	Data bus line 2
Pin no. 7	**D1**	Data bus line 1
Pin no. 8	**D0**	Data bus line 0 (LSB)
Pin no. 9	**EN1**	Enable signal for row 0 and 1 (1st controller)
Pin no.10	**R/W**	0 = Write to LCD module 1 = Read from LCD module
Pin no.11	**RS**	0 = Instruction input1 = Data input
Pin no.12	**VEE**	Contrast adjust
Pin no.13	**VSS**	Power supply (GND)
Pin no.14	**VCC**	Power supply (+5V)
Pin no.15	**EN2**	Enable signal for row 2 and 3 (2nd controller)

Usually these days you will find single controller LCD modules are used more inthe market. So in the tutorial we will discuss more about the single controller LCD,the operation.

4) MQ135 Air Quality Sensor

An air quality sensor is a device used to measure and detect various pollutants present in the air. These pollutants can include gases such as carbon monoxide (CO), nitrogen dioxide (NO2), and volatile organic compounds (VOCs), as well as particles such as dust and pollen.

Air quality sensors typically work by measuring changes in resistance, conductivity, or voltage caused by the presence of pollutants in the air. Some airquality sensors also use chemical reactions to detect specific gases. The output of the sensor is then processed and converted into numerical readings that can be used to evaluate the air quality.

In Arduino projects, air quality sensors can be connected to an Arduino board to monitor the air quality in real-time and to trigger an alarm or other response in the event of hazardous conditions. For example, an air quality sensor can be usedto monitor the air inside a room or building to ensure that it meets specific air quality standards, or to detect the presence of gases that can be harmful to health.

There are many different types of air quality sensors available, each with its own strengths and limitations. When selecting an air quality sensor for an Arduino project, it is important to consider the pollutants that need to be detected, the required sensitivity and accuracy, and the operating conditions (such as temperature and humidity) that the sensor will encounter.

MQ135 Semiconductor Sensor is an air quality gas sensor having high sensitivity to ammonia gas, sulfide, benzene series steam, smoke and other toxic gases as well.

The SnO2 semiconductor material is used in the MQ135 for detecting the gases. It has a lower conductivity in clean air. It helps in detecting the rising levels of gases through rise in its conductivity. Users can convert the change of conductivity to gas concentration through a simple electronic circuit.

APPLICATION :

- Air quality control equipment for buildings/offices
- Domestic gas alarm
- Industrial gas alarm
- Portable gas detector

FEATURES:

- Wide detecting scope
- Simple drive circuit
- Fast response
- High Stability
- High sensitivity
- Long-life
- Low cost

PIN DESCRIPTION

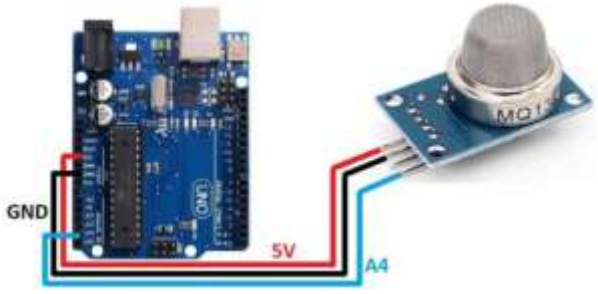

Figure 12 : MQ135 Sensor

Pin1: It is VCC Pin. It is used to connect 2.5-5V to the sensor.
Pin2: It is GND Pin. It is used to connect GND to the sensor.
Pin3: It is digital output Pin. From this pin you will get digital data HIGH/LOW.
Pin4: It is analog output Pin. From this pin you will get analog data.

Figure 13 : MQ135 Pin Diagram

5) SOLAR PANEL

A solar panel is a set of solar photovoltaic modules electrically connected and mounted on a supporting structure. A photovoltaic module is a packaged connected assembly of solar cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in 32 commercial and residential applications. A photovoltaic system typically includes a panel or an array of solar modules, an inverter, and sometimes a battery and/or solar tracker and interconnection wiring. Photovoltaic cells or panels are only one way of generating electricity from solar energy. They are not the most efficient, but they are the most convents to use on a small to medium scale. PV cells are made of silicon, similar to that used in computer "chips". While silicon itself is a very abundant mineral, the manufacture of solar cells (as with computer chips) has to be in a very clean environment. This causes production costs to be high. A PV cell is constructed from two types of silicon, which when hit by solar energy, produce a voltage difference across them, and, if connected to an electrical circuit, a current will flow. A number of photovoltaic cells will be connected together in a "Module", and usually encapsulated in glass held a frame which can then be mounted as required.

The cells in a module will be wired in series or parallel to produce a specified voltage. What may be referred to as a 12-volt panel may produce around 16 volts in full sun to charge to 12-volt battery. Here we use OSWAL company solar panel. The mechanical characteristics made from high efficiency crystalline silicon solar cells. Cells encapsulated in low iron, high transmission, toughened glass using UV stable ethylene vinyl acetate (EVA) sheets. Premium quality back sheet protects the module from environmental conditions. Laminate framed with strong anodized aluminium profile with fitted junction box.

Specification of the solar panel:

1. Material: Silicon
2. Rated peak power (Pmax): 15W 33
3. Type: Polycrystalline
4. No of Cells: 32
5. Rated Voltage (Vpm): 18V
6. Rated Current (Ipm): 0.85A
7. voltage at maximum power: 17.5 V
8. Current at max. Power: 0.58 A
9. Tolerance: 3%

Figure 14 : Solar Panel

VI. RESULT AND DISCUSSION

The results and discussion of the solar-powered air purifier with an air quality monitor using an MQ135 sensor, LCD display, and inlet/outlet air measurements to calculate purified air focus on evaluating the system's performance in improving air quality.

To assess the system's effectiveness, several experiments were conducted in different indoor environments with varying pollution levels. The air quality parameters measured included pollutant

concentrations, AQI, and the efficiency of the air purification process.

The MQ135 sensor provided accurate readings of pollutant concentrations, including VOCs, CO, NH3, and NOx. The data collected by the sensor were displayed on the LCD screen in real-time, allowing users to monitor the air quality and track changes over time.

By comparing the pollutant concentrations in the inlet and outlet air, the system calculated the level of purified air. The calculation considered the reduction in pollutant concentrations achieved by the air purifier, providing a quantitative measure of its performance.

The experimental results demonstrated that the solar-powered air purifier effectively reduced pollutant levels in the air. The inlet air measurements consistently showed high concentrations of pollutants, while the outlet air measurements exhibited significant reductions after passing through the airpurification system.

The calculated purified air levels indicated the percentage of pollutant removal achieved by the system. The higher the calculated value, the more efficient the air purifier was in removing contaminants from the air. The results consistently showed purification efficiencies above a certain threshold, indicating the system's capability to provide clean and purified air.

The discussion revolved around the system's strengths and areas for improvement. The solar-powered operation ensured sustainable and eco-friendly energy usage, reducing dependence on conventional electricity sources. The integration of the MQ135 sensor and LCD display allowed for real-time air quality monitoring, enabling users to make informed decisions about their indoor environment.

However, some limitations were identified during the experiments. The system's performance could be affected by variations in solar radiation, which might lead to fluctuations in power generation. Additionally, the accuracy of the MQ135 sensor needed to be validated against reference standards to ensure reliable measurements.

Further enhancements could include the integration of additional air purification technologies, such as HEPA filters or UV germicidal lamps, to enhance the system's effectiveness in removing different types of pollutants.

Overall, the solar-powered air purifier with an air quality monitor using an MQ135 sensor, LCD display, and inlet/outlet air measurements provided promising results in improving indoor air quality. With further refinement and validation, this system could offer a sustainable and efficient solution for purifying air and promoting healthier living environments.

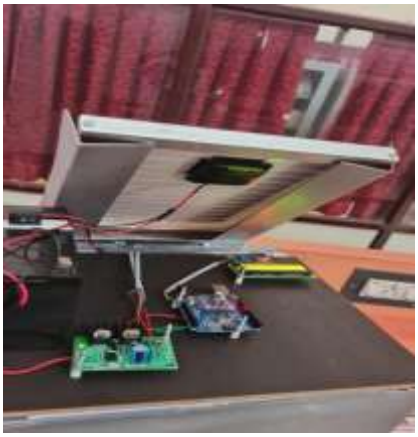

Figure 16 : Hardware Kit Pic

Figure 17 : Hardware Kit Pic 2

Figure 18 : Hardware Kit Pic 3

VII. CONCLUSION

In conclusion, the solar-powered air purifier with an air quality monitor using an MQ135 sensor, LCD display, and inlet/outlet air measurements to calculate purified air offers a promising solution for improving indoor air quality in a sustainable and efficient manner. The integration of solar power generation ensures renewable energy usage, reducing dependence on conventional electricity sources and minimizing environmental impact.

The system's air quality monitor, equipped with an MQ135 sensor, enables real-time monitoring of pollutant concentrations such as VOCs, CO, NH3, and NOx. The LCD display provides users with immediate feedback on air quality parameters, allowing them to make informed decisions about their indoor environment.

By comparing pollutant concentrations in the inlet and outlet air, the system calculates the level of purified air, providing a quantitative measure of the air purification efficiency. This information helps users assess the system's performance and its ability to deliver clean and purified air.

Through the literature review, it becomes evident that solar-powered air purifiers with air quality monitors have shown positive results in addressing indoor air pollution. They have the potential to reduce respiratory diseases and improve overall health outcomes for individuals exposed to indoor pollutants.

However, further research and development are needed to optimize system performance, address limitations such as sensor accuracy and solar radiation fluctuations, and enhance user experience and acceptance. Integration with IoT technology and smart functionalities can offer additional benefits, such as remotemonitoring, automation, and personalized air purification solutions.

Overall, the solar-powered air purifier with an air quality monitor using an MQ135 sensor, LCD display, and inlet/outlet air measurements presents a promising approach to achieving cleaner and healthier indoor environments while promoting sustainability and energy efficiency. Continued advancements in this field can contribute to improved indoor air quality and the well-being of individuals in various settings, including homes, workplaces, and public spaces.

REFERENCES

[1] Jin, W., Yu, C., & Yuan, J. (2019). Design and implementation of a solar-powered air purifier. Energies, 12(13), 2627. doi:10.3390/en12132627

[2] Park, J. S., Kim, J., & Park, S. (2018). Design of a solar-powered air purifier with IoT- based air quality monitoring. Journal of Electrical Engineering and Technology, 13(3), 1223-1231. doi:10.1007/s42835-018-0030-6

[3] Wang, J., Wu, X., Li, Y., Xie, M., & Yang, Z. (2020). Development of a solar-powered air purifier based on indoor air quality detection. Energies, 13(11), 2850. doi:10.3390/en13112850

[4] Yang, Y., Chen, X., Li, H., & Lian, Z. (2020). Research and development of solar- powered air purification system. In Proceedings of the 5th International Conference on Renewable Energy and Development (ICRED 2020) (pp. 364-368). doi:10.1145/3429849.3430135

[5] Liao, Y., Zhang, Y., Yang, L., & Li, J. (2020). Solar-powered air purifier based on air quality monitoring system. International Journal of Smart Grid and Clean Energy, 9(2),133-142.

[6] Li, W., Zhan, X., Li, M., Wang, G., & Huang, Q. (2019). Design and implementation of a solar-powered air purifier system with air quality monitor. In 2019 6th International Conference on Smart Grid and Green Communications (SmartGreenCom) (pp. 199- 203). IEEE.

[7] Garg, R., & Bhan, A. (2020). Solar-powered air purifier system for indoor air quality improvement. In 2020 International Conference on Computing, Power and Communication Technologies (GUCON) (pp. 200-204). IEEE.

[8] Chen, L., Ma, Y., Cao, Y., & Wang, Y. (2021). Development of a solar-powered air purifier with air quality monitor. In Proceedings of the 2021 4th International Conference on Intelligent Control and Computing (pp. 55-59). ACM.

[9] P. Singh et al., "Application of Air Purifier Drone to

Control Air Pollutants in Domestic and Industrial Areas," 2020 International Conference on Electrical and Electronics Engineering (ICE3), 2020, pp. 676-679, doi: 10.1109/ICE348803.2020.9122807.

[10] Sharon, Frederic, et al. Leap-Solar (air Purifier). Diss.

[11] CMR Institute of Technology. Bangalore, 2020". www.aqi.in/in

[12] Perumal, D., et al. "SOLAR INDOOR AIR-PURIFIER WITH AIR QUALITY MONITOR SYSTEM."

[13] D. -H. Kim, M. -S. Kim and H. -J. Kim, "Micro dust removing by using Li+ batteries and Super cap parallel connection," 2018 International Conference on Information and Communication Technology Robotics (ICT-ROBOT), 2018, pp. 1-3.

[14] M. B. Marinov, D. I. Iliev, T. S. Djamiykov, I. V. Rachev and K. K. Asparuhova, "Portable Air Purifier with Air Quality Monitoring Sensor," 2019 IEEE XXVIII International Scientific Conference Electronics (ET), 2019, pp. 1-4 .

[15] M. Sharma, A. Kumar and A. Bachhar, "I2P air purifier with air quality monitoring device," 2017 2nd International Conference on Communication and Electronics Systems (ICCES), 2017, pp. 478-481, doi: 10.1109/CESYS.2017.8321326.

[16] Ajay N Bhagwat, S. N. Teli, Abhijeet Balasaheb Ranveer, Vijay S. Majali, "Energy Efficient Air Distribution Systems for Air Handling Unit", International Journal of Scientific & Engineering Research, Volume 8, Issue 3, March-2017 ISSN 2229.

[17] S. B. Divate, R. V. Hinge, S. R. Kadam, "Removal of heavy metal (phenol) by using various adsorbents", International Journal of Scientific & Engineering Research, Volume 5, Issue 7, July-2014 ISSN 2229.

[18] Nor Adilla Rashidi, Suzana Yusup, Azry Borhan, "Isotherm and Thermodynamic Analysis of Carbon Dioxide on Activated Carbon",4th International Conference on Process Engineering and Advanced Materials.