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SMART FUME EXTRACTOR

School of Technology
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ACKNOWLEDGEMENTS

Projects are considered to be a bridge between theoretical and practical work that is why I joined this project.

This thesis and efforts would not be possible without some important people and institutes. The complete journey has been a lesson but some lessons and supports are important to be mentioned and remember for long time. First of all, I would like to thanks my parents for their immense support and help. Their trust helped me complete my work although they are not in this anymore to see my achievements but I will always be thankful to them.
I would like to thanks my project supervisor Jukka Matila for his support and teachings.
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I would like to dedicate the work done to my parents for their love and support

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ABSTRACT

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The aim of this thesis was to design and develop a novel smart fume extraction system that can improve working environment by efficiently extracting hazardous fumes from their surroundings. The system purifies air by employing carbon activated filter, smoke detector and 180◦ fan rotation. Air quality is measured and a fan is automatically turned on and its speed is adjusted based on AQI.

The design of the embedded system and its implementation, focusing on the system hardware par, were the key aims of this thesis. The ALTIUM-PCB design software was used in order to develop and manufacture the PCB board.

A prototype fume extraction system was developed and successful tests were conducted to assess the efficiency of the product. Hence the goals of the project were achieved and a successful and reliable smart fume extractor were developed. Based on the results it can be concluded that our product is marketable and its success and acceptance among customers is guaranteed.

Keywords Air purifier, 3d modelling, PCB design, Fume extractor, Carbon activated filter

CONTENTS

LIST OF ABBREVIATIONS

PCB Printed Circuit Board

AQI Air Quality Index

GP General Physician

EPA Environmental Protection Agency

OHSA Occupational Health and Safety Administration

MOSFET Metal oxide semiconductor field effect transistor

DC Direct Current

AC Alternating Current

OSHA **Occupational Safety and Health Administration**

LIST OF FIGURES AND TABLES

1 INTRODUCTION

Air purifiers are the devices which clean the air in surroundings from the unwanted and undesired particles from air. These have multiple uses in multiple fields. Consider living in an environment with consistent fumes tendering from all the sides residing in the lungs not knowingly, about their type and components that they are made up of. Almost all of the industries operating today are in dire need of air purifiers not only for the safety of their employees but also for the EPA standards set by the governments.

According to the WHO, the average particle size about 10 microns can penetrate into the lungs and human body, and can cause huge health concerns. Almost 4.2 million premature deaths were resulted in poor air quality with minute particles residing in air[1].

My motivation started while working in a lab for a project in which soldering was applied. I was not prone to any allergic reactions before working on the project. The project went according to proposed plan and I worked on it continuously. The soldering process was also smooth and I was going ahead of my schedule in completion of my project.

I felt some discomfort while inhaling; The problem became consistent so I asked for medical help to sort out my problem. I called onto some local GP and explained my problem. The GP questioned about my work place environment and I explained him that I was working on the project that involved soldering. These words rang the mind of GP and he said then you must be inhaling some unwanted and undesirable products into your body without knowingly. I explained him that I am not employed to any industry it's just a lab and his reaction was quite alarming that he had seen many patients with same complaints, and that too working from industries with some how much similar condition.

[1] Organization, WHO (2018)

Fortunately my problem was not big enough to be worried for but this was the moment I decided to make something that would resolve the problem faced by me. Another factor that also compelled me to work on the product was that people living near the industries unknowingly were inhaling toxic fumes composed of lead and Tin. This could be the main reason that most of the population was victims of asthma.

The most common effects with dangerously high level of particles (carcinogenic Particles) have resulted in lung cancer, heart diseases and stroke worldwide. Soldering is the common process in which two metals are joined together by melting solder[2] (TWI, n.d.). Solder is a metal alloy made of tin and lead which is melted using hot iron. During the process of soldering certain fumes tend to originate from the site upon which soldering is conveyed upon.

Electric soldering can commonly be seen on the mobile repairing shops where they tend to solder some materials. These shops tend to apply soldering principles to set the devices.

Some of the common types of soldering are

a. Soft Soldering

   This process has the lowest filler melting point of all the soldering types, i.e. less than 400 $^{\circ}$C. These are alloys which often contain lead and their liquidus temperature is under 350°C. The low temperature ranges with this type of soldering often limits its usage for certain metals as its strength and durability is low.

b. Hard Silver Soldering

   Brass and silver are used in this process and a blowtorch is used to achieve the required temperature which is >450°C.

c. Brazing (>450°C)

[2] TWI. (n.d.).

This type of soldering uses metal with much higher melting points than hard and soft soldering. More complex materials are soldered using this technique.

I searched on the internet about Fume extractor that are currently present in the market as discussed below.

2 FUME EXTRACTORS

A fume extractor works simply by pulling particles from the air, these heavy particles move by the force of rotating fan as they are heavier than the air molecules; thus, they are easily separated with a blow. Figure 1 shows working of a simple fume extractor.

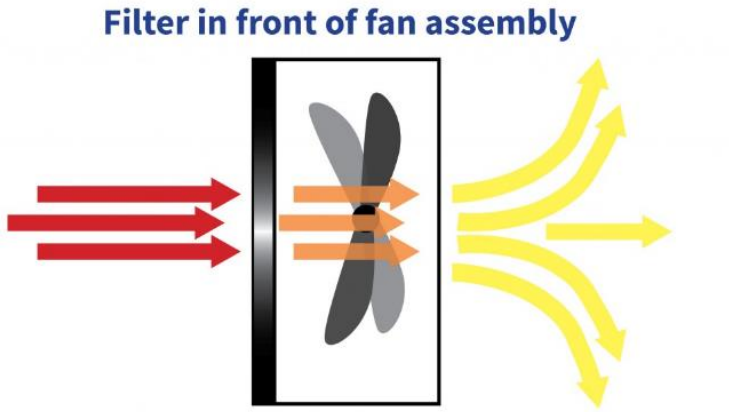

Figure 1. Fume Extractor working principle[3]

2.1 Significance of Fume Extractors

The welding manufacturers have to comply with the air quality standards made for the safety of the employees working in the environment. If fumes tend to move freely in an industry, they can pose threat to the lives of employees and the industry would be liable to penalty. Abundance of fumes in air with composition of carbon dioxide may cause suffocation in an industry which can be unavoidable catastrophe.

[3] Sentry Air+ year.

2.2 Need for Fume Extractor

Fumes contain many harmful particles including tin and lead, which are potentially harmful and damaging for health. To avoid these types of fumes we have to use a fume extractor which captures the particles and purifies the air. Thus, fume extractor plays a vital role in not only saving the human lives but potentially giving benefit to the environment. Some countries have made fume extractors obligatory in industries which can sublet small particles in air.

There are two main categories of Fume systems presently available in the market. All the other fume extractors mainly fall in the sub category of these two types of fume extractors.Fixed Welding Fumes Systems

Fume system use galvanized pipes to extract the fumes originating from welding and fumes are directed outside the building from the carrying hoods that reside on the galvanized pipe.

The main drawback that fixed welding fumes have is its static appearance and its fixed installation at a specific point. Moreover, the fumes directed out do not basically resolve the problem.. The main aim should be the complete removal of fumes.

2.3 Movable Extracting Fume Systems

Movable extracting fume systems are also called mobile fume systems that operate on the demand. For example, in a place with poor air quality, fumes can be deployed and the work place can be secured. They have more advantages than fixed fume operating system.

2.4 Types of Fume Extractors

Some of the most used fume extractors in the market are:

2.4.1 Portable Fume Extractor

Portable fume extractors are light weight and they can be placed in work environment to extract fumes. They must be placed around the environment in which soldering is being taken place.

Figure 1. Portable Fume Extractor[5]

2.4.2 Benchtop Fume Extractor

As the name suggests, these types of fume extractors are placed in the laboratory on work bench to they remove/purify the surroundings from soldering. Sometimes the surrounding gets polluted due to a chemical reaction that they tend to clean.

Figure 2. Benchtop Fume Extractor[6]

2.4.3 Table Top Fume Extractor

Table top fume extractors are also known as shelf mounted fume extractors. They are small in size and have less capacity to filter the air , so they are a very simple type of fume extractors.

[5]sentryair..
[6]sentryair.

Figure 3. Table Top Fume Extractor[7]

2.4.4 Wall mounted Fume Extractor

As can be seen in Figure 5, wall mounted fume extractors have the same principle as of the table mounted fume extractor but they are placed on wall.

Figure 4. Wall Mounted Fume Extractor[8]

[7] sentryair
[8] sentryair..

2.4.5 Stand Mounted Fume Extractor

The stand mounted fume extractors are mobile and can be moved according to the needs as they are placed on movable stands. They are preferred in industries for their mobility and safety.

Figure 5. Stand Mounted Fume Extractor[9]

3 PROBLEM STATEMENT

Reading from above mentioned data it is obvious to question that with all such types of extractors available in the market why we are confident about the success of our product in such competitive market?

3.1 Carbon Activated Smart Fume Extractor (Our Product)

As described above these fume extractors may be portable but they tend to work inefficiently. As seen from the figures they have an angle of 90° and with that much of the fumes will still be in the surroundings. They can become a potential threat if they are left unattended.

The Smart fume extractor revolves around 180° the blower/fan which would be able to catch maximum amount of lead and tin particles that reside in the air. Multi angle blades

[9]sentryair.

increases the performance of the carbon activated filters and and can potentially have an advantage to above mentioned extractors.

The Smart Fume Extractor may look expensive but it surely is not compared to the problems it resolves. Health claims are a common problem faced by the industries with their employees. Most of these claims revolve around allergy and respiratory problems. The reason for these immense claims is that the proper safety measures are not ensured in the industry, causing problems later on. These problems are more expensive to deal with than to install the safety equipment. Moreover, the local law enforcement authorities who are tasked to check the safety standards of the industries may impose heavy fines if the requirements are not met at the first place.

The smart fume extractor was developed for the industry to remove unwanted particles from their surroundings to control the level of pollution. The Smart Fume Extractor, a device which can readily remove harmful particles from air and protect the health of the workers and other living creature residing in the area.

Another advantage of the product over the others is carbon that is placed inside the extractor behind the fan/blower. The carbon particles being purely organic have the tendency to capture lead, tin and zinc from the air more efficiently than any other product. The carbon can be replaced once it has attains its life. The replacement is easy and can be done on spot without any expert knowledge; any worker if taught once can replace it. Moreover, the surrounding air can also be cleaned.

The cost of the product is low, its simple design will attract much of the clients, as the main focus of the industries is that the product they intend to buy is in the approach of workers and its operation is user friendly.

The third world countries can be a potential and targeted market. With a low price, higher units could be sold and with god consumer reviews there may be a possibility to enter in more competitive market. The EPA standards are the same for all the countries. The reason these countries tend to ignore the standards is the cost of installing such safety products. The smart fume extractor being low cost could easily tap this untapped market.

The quality of the product is seen to be exceptionally higher than those of its competitors. Timely innovations can be added in the product such as placing a tiny sensor which can tell us when to replace the carbon inside the fume extractor.

The mobility of the fume extractor would also be advantageous it can be placed in any section of the industry. The barratries manufacturing industry has sulfuric fumes in the surroundings as sulfuric acid is their main component in the manufacture of their goods.

As our competitors have old technology, they are likely to leave much of the tiniest particle in air which can cause harmful effects on the workers and people living in that particular area. The smart fume extractor has the efficiency of above 95% in eliminating lead, zinc and tin which are considered as the basic components evolved from the soldering.

3.2 Reducing Exposure to Welding Fumes in Work Place

According to OHSA (**Occupational Safety and Health Administration**), welding manufacturers are required to provide with information and training on hazardous materials in work place so they should be well aware of dangers of their job. Once they came to know how much sensitive work they apply for the industry, they should be able to protect themselves in a much better way. No matter what safety measures are instructed if an employee does not comply with them. . The Hazardous Communication Standard (HCS) provides a coherent approach to classifying chemicals and communicating their hazardous information on their labels and other safety materials. Safety associations recommend the regular inspection of the ventilation system and their cleaning on regular basis.Other terms in order to reduce the fumes from going into the atmosphere certain things can be done which are as follows:

a. Welding surfaces and countertops should be thoroughly cleaned of any coating or residue that could create toxic exposure to employees.
b. Employees and factory workers should position themselves to avoid breathing in hazardous welding fumes and gases.

c. A proper ventilation system can help the moment of fresh air in the facility to reduce the level of unwanted fumes and gases.
d. Fixed mobile devices can be placed near the work place of an employee.
e. Workshops and first aid seminars should be arranged on regular basis for the safety of employees in order to prepare for any calamity that could potentially harm the employees.
f. For industries with less ventilation system due to abundance of space and area. Welders should be guided to use natural drafts to remove unwanted particles from their sites.

3.3 Selection Criteria for Fume Extractor

Not every type of fume extractor can be placed in any industry. The selection criteria for a fume extractor will depend on the size of industry and the potential threat that the industry can produce in terms of fumes. More specifically in terms of materials and products which are to be manufacture in particular industry. Some points that should be considered while installing the fume extractor are:

a. The type of welding process which is being used for soldering or other welding process irrespective of the type of industry.
b. The composition of the welding rods and the components that could be present, this helps in viewing the contents that could be present in fumes and from them the specific type of extractor can be planted.
c. The location of the factory or industry, whether there is much space or in terms of ventilation and spacing can be brought to light before installing the fume extractor.
d. Air movement in the facility also plays an important role for the selection of the type of fume extractor to be installed.
e. The base metals and materials that are to be used such that they cannot pose any threat if the materials are reacted in fume extractor.

3.4 Chemistry behind Fumes and Reactions

3.4.1 Lead Reaction with Air

The air in Earth's atmosphere is made up of approximately 78 percent nitrogen and 21 percent oxygen,1% has small amounts of lots of other gases, too, such as carbon dioxide, neon, and hydrogen. As there are many gases in the air that could react with the pb fumes when we perform soldering. but for nitrogen as it is the inert gas and is not able to react with the lead. So only Oxygen is remaining there to react with the pb fumes create lead oxide as shown in the equation.

$2Pb_{(s)} + O_2 \rightarrow 2PbO_{2(S)}$ (Elements, 2020)

[10]Lead is present in form of fumes and small discrete particles that can be rendered as solids .Nitrogen is an inert gas that is present `in air only oxygen is left for the reaction. The temperature for soldering is above >450˚C thus this reaction can happen.

3.4.2 Lead in Air Hazards (EPA, 2014)

[11]Once the lead present in air in forms of fumes is inhaled in the body, it tends to deposit in blood and bones. As it is heavier than oxygen, it readily stays there. Lead can damage kidneys, it depends on how long the person has been exposed to the hazardous component. Asthma is something more of common if lead attached on lungs. It can be a potential threat, such as complications from COVID-19 as it is a respiratory disease nowadays.

3.4.3 Zinc and Tin Reaction with Air

Zinc reacts with oxygen at around 800˚C to form zinc oxide. The fumes can be regarded as the solid particles in air. Similar reaction is with tin, both of these reactions and compounds generated are extremely dangerous for health.

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[10] Elements, R. o. (2020.

[11] EPA. (2014

When zinc is inhaled through air, it tends to increase the amount of zinc in blood, which potentially lowers the level of iron in the body and it thus potentially damages the bones and can cause severe consequences. Low levels of copper tend to arise with exponential intake of zinc in forms of fumes which can cause headaches and low immunity levels.

Tin on the other hand damages teeth and can cause bleeding and can potentially damage other important organs in the human body. Thus, it is important to make sure that the environment and the surroundings is free from all such unwanted particles.

4 PRODUCT DESIGN

This block diagram in Figure 7 shows the overall product working principle and components used. The block diagram shows major components, working and interconnectivity of the system. The input power of the system is 12V which is then converted to 5V power through buck conversion IC. This 5V is then supplied to the smoke sensor MQ2, servo motor, potentiometer and to a micro controller.

The micro controller controls the fan speed with the help of PWM and when it should turn ON and OFF. This decision is taken by the micro controller on the basis of feedback that micro controller receives from the MQ2 smoke sensor. The speed of fan depends on the quality of the air: if the air quality is bad, the speed of fan increases and as the quality air is improved, the speed of the fan reduces accordingly.

The servo motor is used to control the rotation of the fan. For this purpose, a potentiometer is used that will change the angle of the servo motor on the basis of variable voltage. A potentiometer gives feedback to the micro controller and on the basis of potentiometer value, the servo motor will rotate accordingly which in turn change the rotation of the fan.

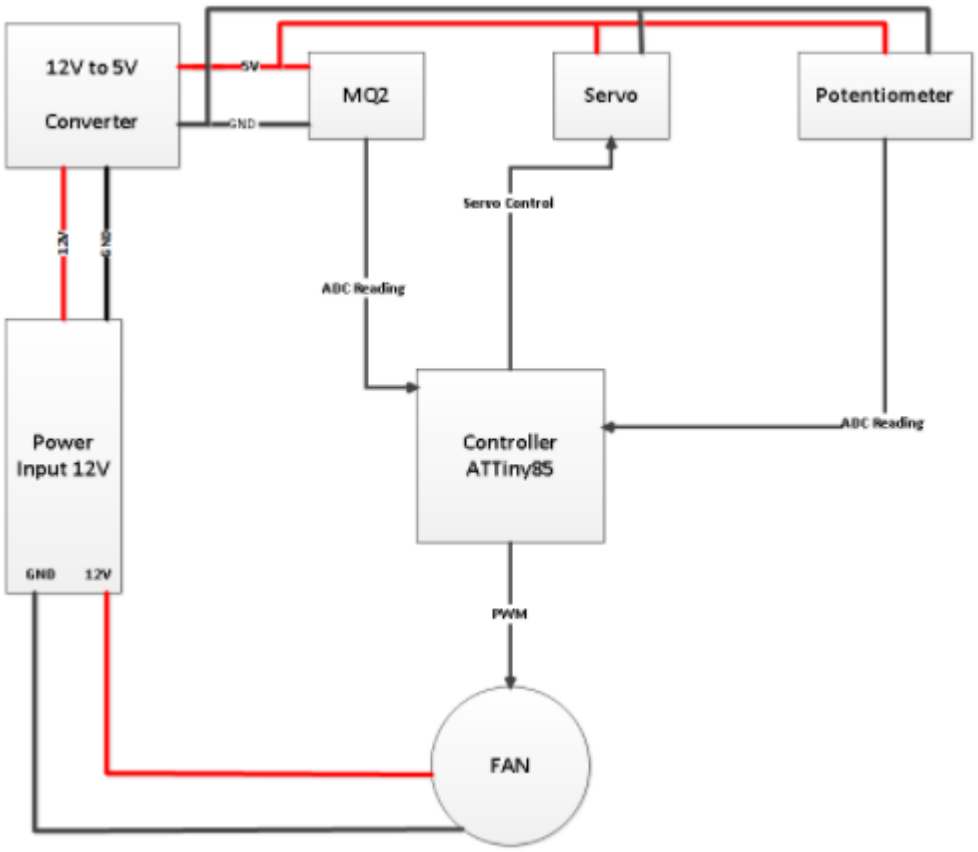

Figure 6. Block Diagram

4.1 Schematic Design

The circuit schematic of the project was designed using the Altium software. Initially the schematic of the smart fume extractor was designed. Each component of the circuit and their inter-connectivity with each other has been outlined in the schematic. The schematic was designed to achieve the desired output efficiently. The schematic circuit design is divided into four different segments as follows

a. DC Input and System Power
b. Power conversion
c. Controller Section
d. Servo Motor Control

Following sections will explain working of each segment subsequently

4.1.1 DC Input and System Power

In this segment of the schematic, the following electrical components have been used to obtain input power of 12 V for the system

Ser	Electrical Component	Working Principle
a	N-MOSFET	The system will take high current to operate the whole system and slide switch may not be able to sustain the high current for longer time, so in order to overcome this Situation a N-MOSFET(Q2) is used. As we know MOSFET's are used for switching purposes and they can allow high current to pass.
b	Slide switch	Slide Switches are meant to be used as power ON/OFF controllers. The Slide Switch will change the logic on GATE of MOSFET (0V System OFF/12V System ON).
c	Resistor	The Resistor R1(10K) is used to pull down the Gate to restrict any floating state.
d	DC jack	J3 is a female DC jack component used for power input of the systems

The circuit will be able to provide Input power of the system 12v.

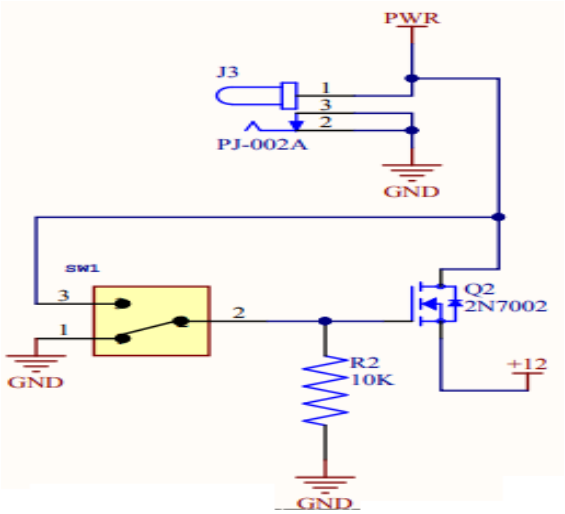

Figure 7. DC input and System Power

4.1.2 Power Conversion

The input power of the system is a wall adapter of 12V but most of the electronics components used in the design, such as micro controller, servo motor, and smoke detector. work at 5V DC. So, for this purpose we need a power conversion from 12V to 5V. Two type of voltage converting technologies/IC are used for power conversion. One is linear regulation which is done by voltage drop and uses no feedback to maintain the fixed voltage. In addition it uses high current. On the other hand, the second method is switching regulation, which is done with a feedback and PWM so that fixed voltage is maintained. For this purpose power conversion has been performed using switching regulation and TPS560430 IC used for the power conversion. The output voltage is monitored constantly through feedback and PWM based switching used to maintain the desired Output of 5v DC Constantly.

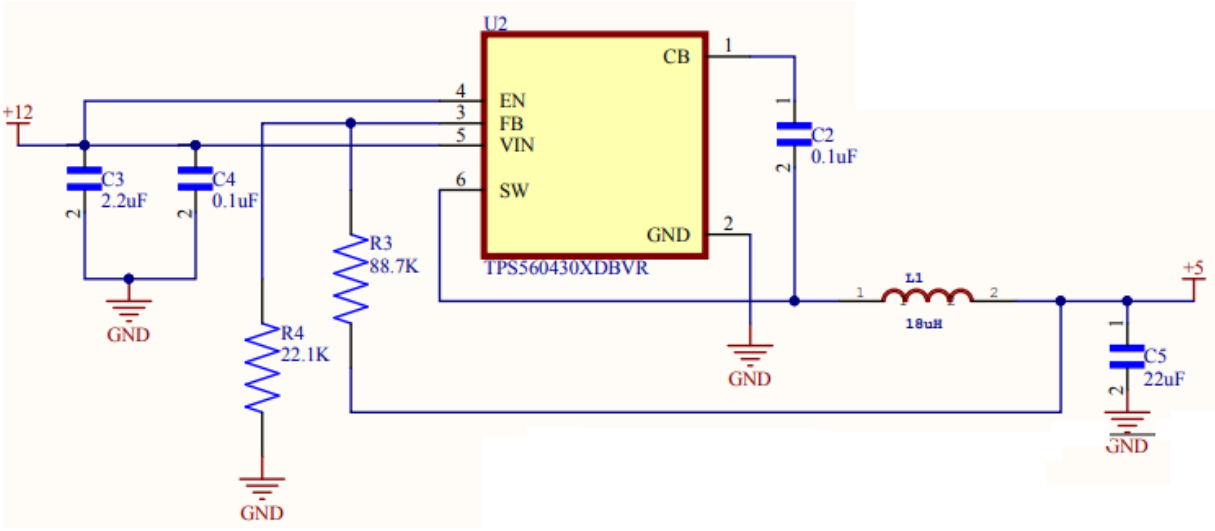

Figure 8. Power Conversion from 12V Input to 5V Output

4.1.3 Controller Section

The controller controls the working of the whole product. It consists of following electrical components:

Ser	Electrical Component	Working Principle
a	micro controller (AT-tiny 85)	Micro controller is used to control all the sensors and electrical components and make decisions based on Information provided by the sensor.
b	N-MOSFET	As Fan works at 12v so we add a MOSFET to use it as a switch to control the power as micro controller Pin is not able to handle 12V.
c	Capacitors	Capacitor C1 is used at the input of the micro controller to avoid any random spike in the voltage that could be harmful for the micro controller.
d	Servo Motor	The Servo connections are shown with Header J3.
e	Fan	Fan was connected at the J4 Header

f	Programming Connector	J1 connector is used to program the micro controller.

The smoke detector will detect the smoke from the environment and micro controller gets the feedback from the sensor and turns ON/ OFF the fan on the basis of sensor feedback. The speed of fan depends on the air quality of the environment. The schematic is shown in Figure 10 below

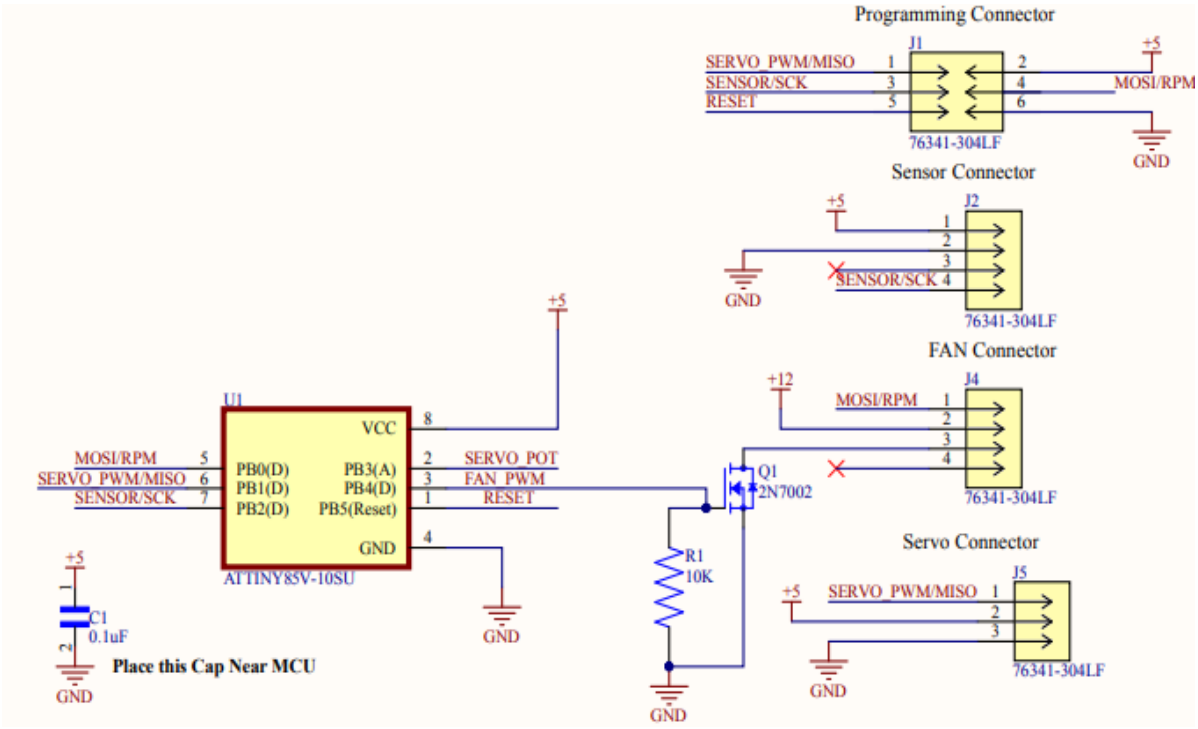

Figure 9. Controller Section

4.1.4 Servo Motor Control

The servo motor is used to rotate the direction of the fan. The servo motor can rotate from 0 to 180 degrees. To control the rotation of the fan manually, the potentiometer is used to change the direction of fan. The voltage drop across the potentiometer will be read with an ADC pin and movement will be mapped accordingly.

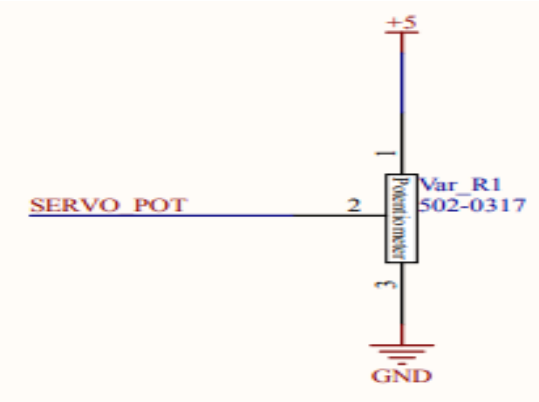

Figure 10. Servo motor Control

4.2 Software Development

After the successful circuit and PCB design, a code was written to program a micro controller and test the functionality of the circuit. For this purpose as AT Tiny85 microcontroller was used, the code was written in the Arduino IDE development software. The flowchart for the firmware is shown below. However, the code is provided in Appendix "A"

Delete this empty space somehow.

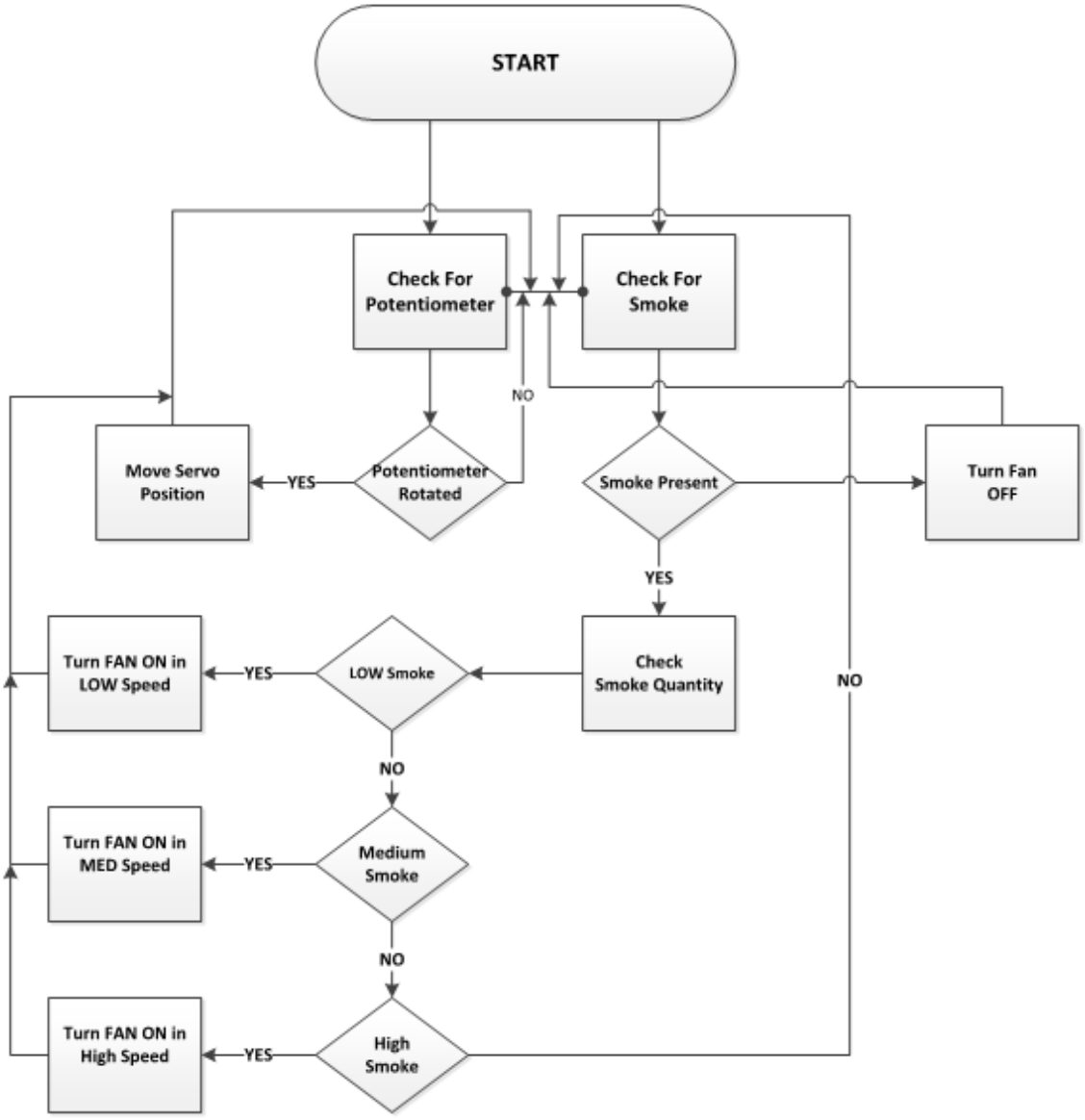

Figure 11. Flow chart

4.2.1 Explanation of flow Chart

Figure 12 shows the flow chart of the firmware that was written to achieve desired output from the product. Whenever the program starts, it will check two things initially. First, it checks whether the potentiometer is used or not and if yes then it will rotate the servo motor accordingly. If not, then it will check for the potentiometer to change its value. Secondly, it will get the readings form smoke sensors. If there is no smoke, then the fan remains off and it will check for the smoke again. If yes, then it will turn on the fan. It

will also check the quality of the air and with respect to the air quality, it will change the speed of the fan. This cycle is repeated.

4.3 PCB Design

The PCB is designed to give life to circuit design and to develop design physically. It is used to test the circuit and working of product. After successful schematic design the Altium PCB software was used to design the PCB of the product as shown in Figure 13 below.

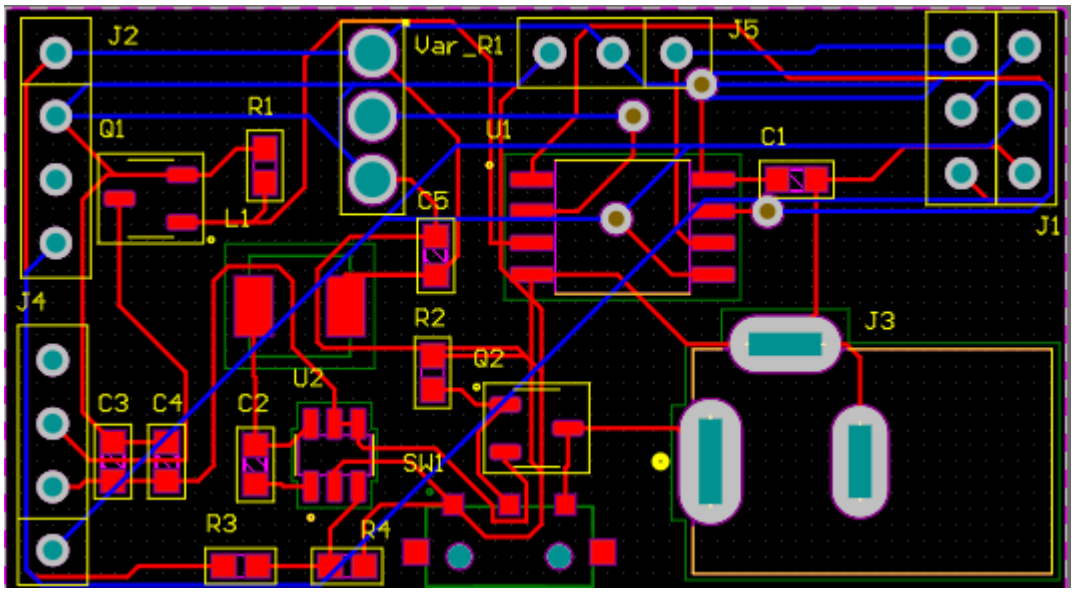

Figure 12. PCB Layout

The PCB board has two layers. Red and Blue lines show electrical wiring between components. J2, J3 and J4 are through holes connectors for potentiometer, sensor, fan and motor. J1 is the programming header called SPI connector used for programming the micro controller. Foot prints with subscript R, C and Q are for the resistors, capacitors and MOSFET respectively. U1 and U2 are for the power conversion IC and Micro Controller.

4.4 PCB Manufacturing

Processes involving the manufacture of PCB are described next.

4.4.1 Provisioning

All the much-needed components required for the project were obtained from cabinet located in front of LEC-4 in “Technobothnia”. The user guide was available for the components to be used. As stated before that all the components were to be found at VAMK libraries. Taking all the necessary components and materials necessary for the project alongside were placed in manufacture room PCB. The board was established where the components and connections were about to be placed. The items were located inside the cabinet room; the boards were one or two sides of copper. The particular project needed one side board.

Once all the material were in possession, and the circuit was printed on transparent paper and board, all was set for the manufacturing of PCB.

4.4.2 Vacuum UV Exposing Device

To achieve the goal of the manufacture of PCB, this device is extremely important. The device is equipped with special UV lamps and auxiliary suction device. In order to operate the user has to remove adhesive from the board, put the transparent paper face up in the UV device, with side where adhesive face is down and then close both covers of UV device.

There are two covers the inner one, transparency film, to make vacuum effect and outer one which will make the UV exposing effect to the top layer. As for the present case the object is a prototype and only one side will be printed in the board using the bottom UV light. It is important to place a vacuum UV explosive device because of the light weight of the board and its sensitivity.

Figure 13. Vacuum UV Exposing Device[12]

It should be noted that the transparent paper should be placed correctly, otherwise it will become very difficult in printing all the components of the circuit. The circuit will only be implemented in a proper way, once PADS layout preview is inverted in bottom part of the board, the components on the top layer and soldering substances in the bottom layer only then the purpose of the circuit will be completed.

After placing the board and film, the user time is set as 3 minutes. The board is formed by insulating layer, then copper layer and then finally covered with light sensitive emulsion. Once the board is exposed to UV radiation, the black part will protect emulsion and emulsions from other parts of the UV will weaken. Now after that the vacuum is to keep the board next to transparent paper without any space between them.

4.4.3 PCB Manufacturing Machine

The machine completes manufacturing process of PCB. It has 5 steps which are described as:

[12] Sergio Javierre , hardware design for a smart lock system for home automation, 2016, VAMK University. I don't think VAMK is the publisher

Figure 14. PCB Manufacturing machine[13]

Step Zero

This step is used to sustain the board with frame, after that the user kicks off to start the program. Careful observation is required by the user as there are a harmful chemical that affects the skin.

Step 1

Turn on the machine and enable a smooth electric flow as required by the machine. The board is submerged in water based offset plate developer solution, where the board will get rid of the weaker part of the solution. The copper layer in these parts would be out layered. It needs couple of minutes with the water hole.

Step 2

Set the time to max and observe the working of the machine. The liquid will be heated in this step. Manufacturing in the transparent paper will be still protected by the emulsion.

[13] Sergio Javierre , hardware design for a smart lock system for home automation, 2016, VAMK University.

Step 3

Two lights can be seen on the machine, one is etching and the other one is used for heating. Etching light must be on while the subject is heating. This is regarded as the most important step. This step contain iron and chlorides which will remove the most external copper layer which corresponds to transparent part of the printed circuit in the transparent film, leaving this part just with the insulated layer. The user must carefully watch this step, when the board color appears yellow instead of Pink that means that PCB is ready.

Step 4

In this step the temperature will rise to 50°C. The heating light will be turned off and the etching process would be much faster. In holes its water and other chemical component which helps to clean the PCB.

4.4.4 Drilling Machine

After the use of PCB manufacturing machine, the board outline can be cut by the user. The user can put the PCB on a smooth surface with no bumps around that might disturb in the process of drilling. The PCB then has to be placed on a wooden plate before drilling. Some metal fringes can be used to drill according to the required size being demanded by the customer.

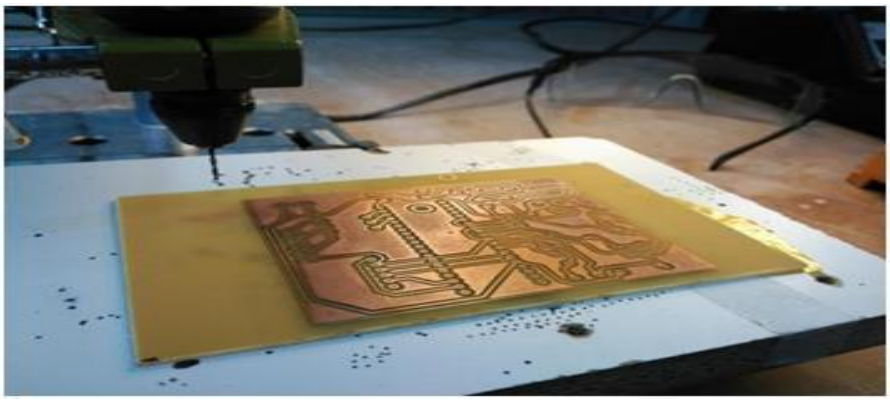

Figure 15. Drilling[14]

Itis important that the user is aware of the potential hazards of drilling and must drill only when it has proper equipment for drilling. The safety equipment in this case will be safety glasses which will protect the eyes from the unwanted materials and gloves to protect the hands. After drilling some alcohol be added if desired in order to clean the PCB.

4.4.5 Soldering Iron

This is the time to put all the components and soldering on board. It is important to mark holes as tin would not perfectly match the desired holes that are required by the user. Place the correct holes in correct places in order to obtain perfection in soldering This is an irreversible process and there is no way for making any sorts of mistakes. Soldering iron with a sharp end will help to avoid the mistakes. The first step to solder is to heat the pad and the terminal of the component with soldering iron for some seconds. After this add tin to the pad until the pad is completely recovered from the tin. Hold the soldering iron for some seconds until the tin is touching the pad. Do not blow the soldering iron, the tip of the soldering iron must be clean.

[14] Sergio Javierre , hardware design for a smart lock system for home automation, 2016, VAMK University.

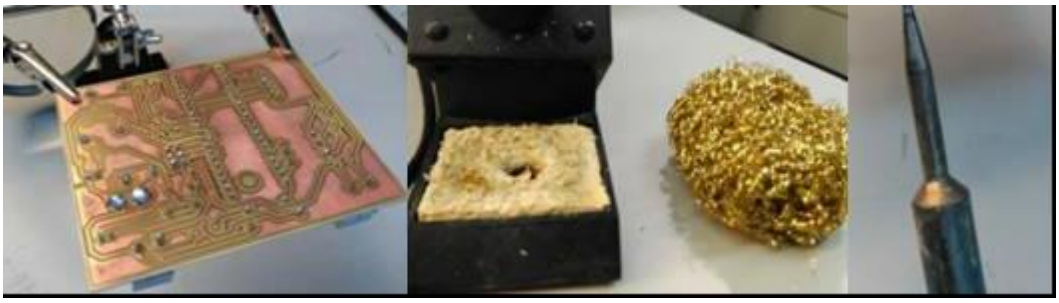

Figure 16. Soldering[15]

While soldering it is important to leave small gaps between resistors and diodes for air to flow this will be beneficial for the component. This project used sockets to connect Microcontroller and HC-05 Module in order to keep them portable and be easily embedded out when required. This project also contains two socket pins to connect an electric strike and indoor button so that both parts can be far away from the embedded system. In this project the user must know how to connect the components take, for example that LEDs have the longer terminal to show the anode. . After soldering the components the prototype is ready to be observed. Gerber and drill files required for PCB manufacturing are shown below.

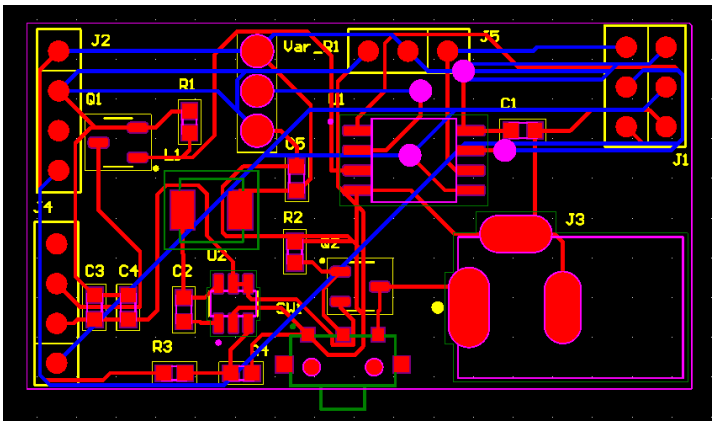

Figure 17. Gerber File

[15] Sergio Javierre , hardware design for a smart lock system for home automation, 2016, VAMK University.

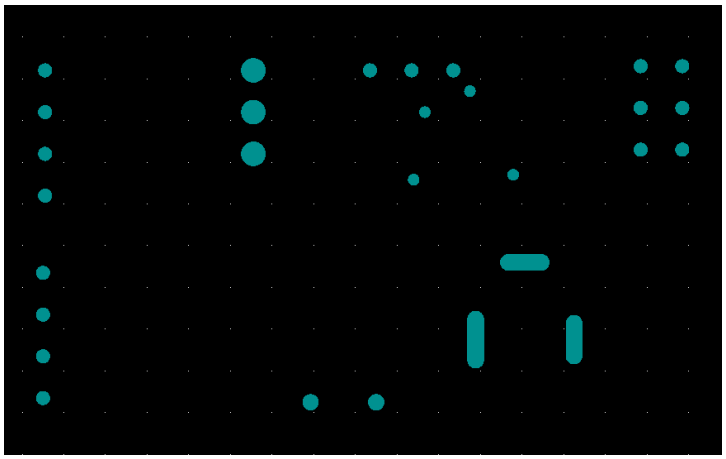

Figure 18. Drill File

4.5 CAD Modelling

3D CAD modelling was performed in the Autodesk Inventor software to give the product physical shape, as shown in Figure 20 below

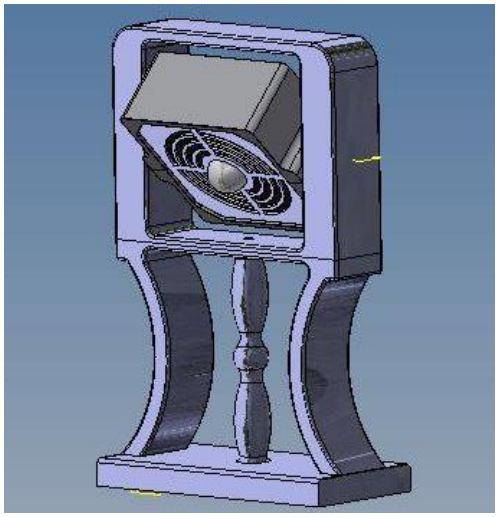

Figure 19. Design of smart fume extractor

A rotatable fan has been integrated at the top. Rotation is achieved with the help of potentiometer. In addition, a center pillar has been incorporated to support the design and better aesthetics. Figure 21below shows location of PCB mount and 180° fan rotation.

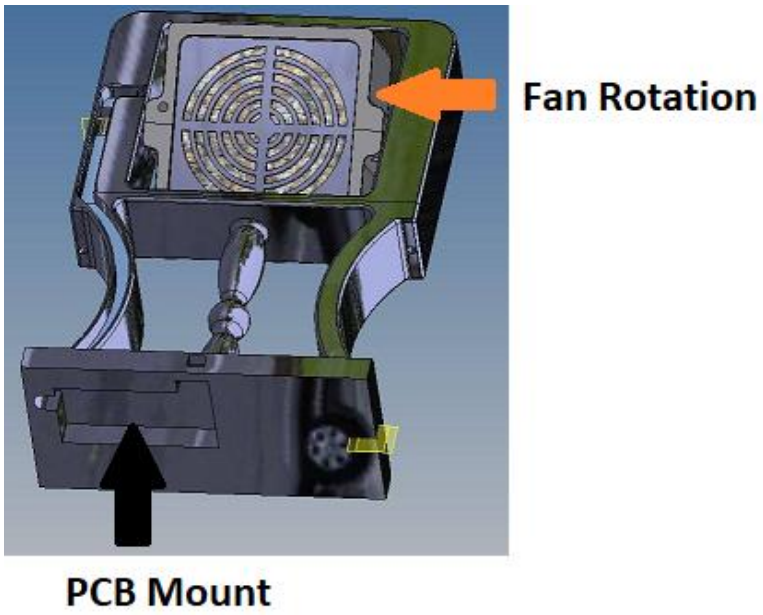

Figure 20. PCB mount and Fan rotation

Figure 22 below shows the path of the wires that will go from the PCB located at the bottom to the fan located at the top

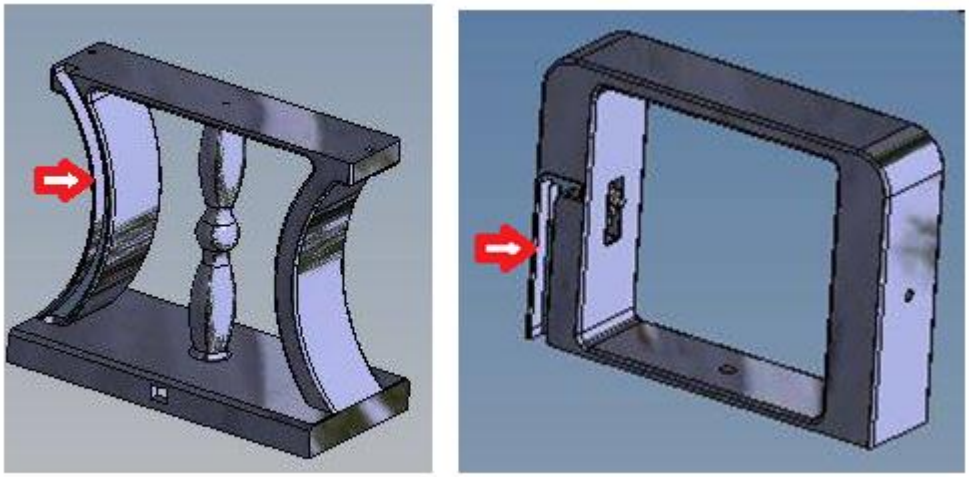

Figure 21. Wire Path

Figure 23 below shows the components of the fan and their placement.

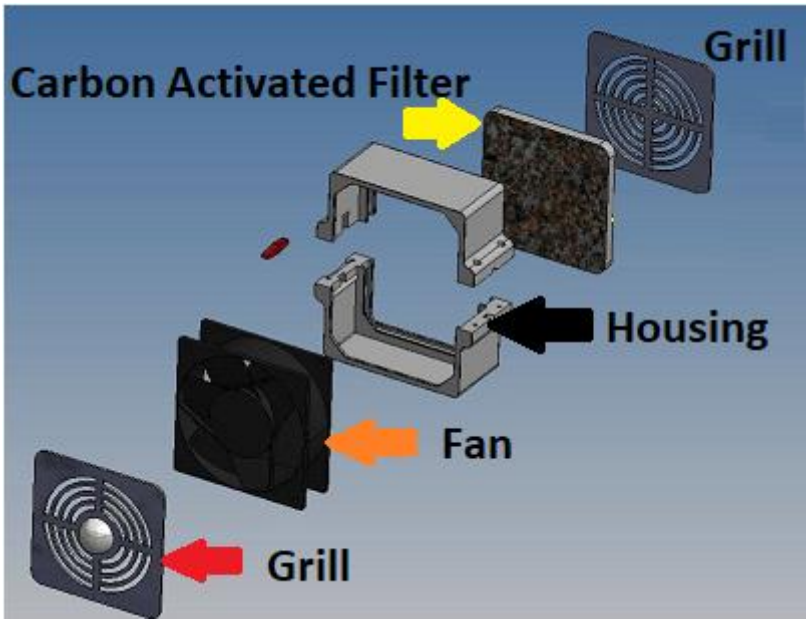

Figure 22. Components of Fan

4.6 3D Printing

The design was 3D printed using ABS material, however due to cracks, fissures and other defects material was changed to PLA.

5 TECHNICAL DESCRIPTION

This section will explain the results and calculation that were made during testing and product design process.

5.1 Power ON/OFF Circuit

Slide Switches are meant to be used as power ON/OFF controllers but the systems uses higher current due to fan and gas sensor. The slide switches are meant for lower ranges of current. For controlling the high current MOSFET as switches are used. The slide switch controls the gate voltage of the MOSFET to CLOSE/OPEN the circuit path. The Resistor R1 (10K) is used to pull down the Gate to restrict any floating state. Also the value of resistor 10K is selected to minimize the leakage current.
5V/10K = 500uA or 0.5mAh.

5.2 Components in the Design:

This section describes all the parts and components used and there chosen appropriate values.

5.2.1 Input Capacitor

The capacitor values are chosen after calculations and the system requirements as using too large value capacitor will also cause delay in power up and power down operations. Capacitors have their charging and discharging time when powered. They are used on power channels in the design. This allows continuous operation of the system in case of power fluctuation or spikes as capacitors maintain the voltage levels for the period.

5.2.2 Buck Converter IC TPS560430

The TPS560430 device requires high frequency input decoupling capacitors. The typical recommended value for the high frequency decoupling capacitor is 2.2 µF or higher. A high-quality ceramic type X5R or X7R with sufficiency voltage rating is recommended. The voltage rating must be greater than the maximum input voltage. To compensate the derating of ceramic capacitors, a voltage rating of twice the maximum input voltage is

recommended. For this design, one 2.2-µF, X7R dielectric capacitor rated for 50 V is used for the input decoupling capacitor. The equivalent series resistance (ESR) is approximately 10 mΩ, and the current rating is 1 A. Also, a capacitor with a value of 0.1 µF for high-frequency filtering is used and placed near on the PCB[16]. (Anon., n.d.)

5.2.3 C2 Bootstrap Capacitor:

Every TPS560430 design requires a bootstrap capacitor, CBOOT. The recommended bootstrap capacitor is 0.1 µF and rated at 16 V or higher.

5.2.4 Output Voltage Resistors

The resistor divider R3&R2 are used to set the output voltage.

If R3 is chosen to be 22.1K and output voltage is to be 5V, So,

R2 =(($Vout - Vref$)/Vref) * R3.

Vref = 1.0V.

The equation yields 88.4k so standard value of 88.7K is used.

5.2.5 Inductor Selection:

The inductor and output capacitor are chosen according to the suggested application diagram in the converter datasheet.

5.2.6 MQ2 Sensor

A gas sensor capable of detecting hazardous gases, such as methane, butane, LPG, or smoke.

The sensor can provide the digital output on given threshold. (Not used in the design).

The analog out pin provids the voltage based on the gases present to the ADC pin of the controller and the controller implements the logics to calculate the value.

The range of sensitivity for the sensor is 300-10000ppm.

[16] Texas Instruments (n.d.).

5.2.7 Fan

12V fan is used to exhaust the hazardous gases in the air. The fan uses a PWM pin connected to controller for operations.

5.3 System Power

The MQ2 sensor uses 50mA of current at 5V during the operation 0.25W

The Fan uses around 300mA at 12V, 3.6W

The Switching converter IC has the operational current in micro amps so its neglected.

The controller uses 8mA at 5V on running at 8Mhz 0.04W.
So the total power consumption of the system is 3.89W or approx. to 4W.

6 TESTS AND RESULTS

6.1 Test Objective: Potentiometer is used to rotate the angle of the servo motor.

Test Steps	Test Results
1- Power on the system	Power on led turned On
2- Move potentiometer to the max	Servo motor move by 180 degree
3- Move potentiometer to the minimum position	Servo motor move to the angle 0
4- Move potentiometer from minimum position to the middle position	Servo motor move by 90 degree

6.2 Test Objective: Fan Speed changed based on smoke detector sensor reading.

Smoke Sensor low threshold 500 equivalent to 33% duty cycle on PWM pin of FAN
Smoke Sensor middle threshold 700 equivalent to 66% duty cycle on PWM pin of FAN
Smoke Sensor high threshold 950 equivalent to 100% duty cycle on PWM pin of FAN

```
#define LOW_SPEED 85
#define MED_SPEED 170
#define HI_SPEED  254
```

Test Steps	Test Results
1- Power on the system.	Power on led turned On
2- Use Gas lighter near the smoke detector sensor	The system will start observing the smoke

3- At Smoke Sensor lower than low threshold	Fan turned on at first speed
4- Let the gas lighter more time near to smoke detector until exceed the second threshold	Fan already ON but fan speed changed to the second speed
5- Let the gas lighter more time near to smoke detector until exceed the third threshold.	Fan already on but fan speed changed to the third speed
6- Don’t use the gas lighter	Fan speed decreased till fan turned OFF.

7 CONCLUSION AND FUTURE ENHANCEMENTS

The main objective of the thesis was to make the life of a Lab worker/Technician healthier. The main concept was chosen after observing the problem in the real-life, efforts were to put in to provide the best solution with the given resources.

As the device is made up of 3D printed parts the overall accuracy and performance is compromised but it proves the idea and showed prominent results in testing phase. The compact and handy design of the device helps in easy installation and can also be operated as working table equipment without taking up minimum space.

As the application directly relates to health of a person so no compromises can be done that is the reason of choosing the “Activated Carbon Filter”. The filter is more expensive than competitor technologies but shows good results and is more effective.

As the idea was to establish a cost-effective solution, some implementations are left for the future enhancements. Some are listed below

- An Occupancy/Motion sensor can be used to detect a sensor so that the fan automatically settles its position facing towards the sensor.
- PM1.0 particle sensor can be used for measuring AQI and operating the fan for air purification.
- The same system can be designed in a bigger size with an AC fan motor and same particle/Smoke Sensor to purify the surrounding of the complete rooms.

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