

Design and Implementation of a Portable Air Purification Device

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Abstract: Portable air purification device play a crucial role in maintaining indoor air quality and promoting a healthy living environment. This study presents the design and implementation of an air purification device aimed at effectively removing airborne contaminants and improving overall indoor air quality. The device incorporates a filtration system, to capture particulate matter, and allergens from the air. Additionally, ultraviolet (UV) light sterilization technology is employed to neutralize harmful microorganisms, such as bacteria and viruses, further enhancing the device's efficacy. The device features adjustable fan speeds and intuitive controls, allowing users to customize operation according to their preferences and environmental conditions. This system produces improvements in indoor air quality, highlighting the effectiveness of the device in providing clean and healthy air for hospital, residential and commercial spaces.

Chapter One

Introduction and Aim of the Project

1. Introduction

The escalating concern over indoor air quality (IAQ) in recent years has brought to light the critical implications for human health, particularly in enclosed environments such as hospitals. With factors like urbanization, industrialization, and the prevalence of indoor pollutants exacerbating the issue, there's an urgent need for effective air purification solutions tailored to healthcare facilities.

Indoor air pollution poses significant risks within hospitals, where vulnerable patients and staff members spend considerable time. Contaminants such as airborne pathogens, volatile organic compounds (VOCs), and particulate matter (PM) can compromise patient recovery and staff health, leading to increased infection rates and respiratory issues. Conventional ventilation and filtration systems, while effective to a degree, often fall short in meeting the stringent IAQ requirements of healthcare environments due to limitations in mobility, efficiency, and maintenance.

By focusing on hospital settings, this project aims to address the unique challenges associated with IAQ management in healthcare facilities. The portable air purification device being developed will leverage advanced technology and filtration mechanisms to effectively remove a wide range of indoor pollutants, including bacteria, viruses, and chemical contaminants. Emphasizing ease of use, mobility, and compatibility with hospital infrastructure, the device will

offer a practical and efficient solution for maintaining clean and healthy indoor air within patient rooms, surgical suites, and other critical areas.

Ultimately, the successful development and implementation of this portable air purification device have the potential to significantly enhance the quality of care provided in hospitals, safeguarding patient health and well-being while supporting the safety and productivity of healthcare professionals. By addressing the specific IAQ needs of healthcare settings, this project aims to contribute to the advancement of air purification technology and promote the creation of healthier indoor environments within hospitals and medical facilities.

1.2. Aim of the Project

The primary aim of a device is capable of efficiently purifying indoor air by removing contaminants such as particulate matter, allergens, dust, smoke, and VOCs using Ultraviolet. Furthermore, the device is compact, lightweight, and portable, allowing users to move it easily from one location to another. Portability enables users to purify air in different rooms in hospitals or areas of their home, office, or vehicle, providing flexibility and convenience.

Chapter Two

Literature Review

2.1. Introduction

In the realm of healthcare facilities, maintaining optimal IAQ is paramount, as it directly impacts the well-being of patients, staff, and visitors. The presence of airborne contaminants, including allergens, viruses, and VOCs, can exacerbate existing health conditions, pose respiratory risks, and potentially hinder recovery processes [1].

Portable air purifiers have emerged as a crucial component in safeguarding IAQ within healthcare settings, offering several compelling advantages:

- **Enhanced Air Filtration:** Conventional Heating, Ventilation, and Air Conditioning (HVAC) systems may not adequately eliminate airborne contaminants, particularly in areas with high patient traffic or limited ventilation. Portable air purifiers, equipped with specialized filters, effectively capture and remove a wide range of airborne particles, including viruses, bacteria, pollen, and dust mites.
- **Reduced Transmission of Infectious Diseases:** Healthcare facilities are inherently susceptible to the spread of infectious diseases, such as influenza and COVID-19. Portable air purifiers, particularly those with HEPA (High-Efficiency Particulate Air) filters, can significantly reduce the airborne concentration of viruses, thereby minimizing the risk of transmission.
- **Improved Patient Comfort and Recovery:** By providing clean, purified air, portable air purifiers can alleviate respiratory symptoms, enhance patient comfort, and potentially expedite recovery.
- **Reduced Sick Leave among Staff:** Exposure to poor IAQ can lead to a variety of health issues, including headaches, fatigue, and respiratory problems, resulting in increased absenteeism among staff. Portable air purifiers can contribute to a healthier work environment, potentially reducing sick leave and enhancing overall productivity.
- **Safer Workspaces for Healthcare Professionals:** Healthcare professionals are at an elevated risk of contracting infectious diseases due to their frequent exposure to patients. Portable air purifiers can play a vital role in minimizing this risk and creating a safer work environment [2].

By incorporating portable air purifiers into healthcare facilities, healthcare providers can take a proactive approach to IAQ management, safeguarding the well-being of patients, staff, and visitors. These versatile devices offer a powerful tool for creating a healthier and safer environment within these critical settings [3].

2.2. Ventilation in Hospitals: A Necessity for Enhanced Indoor Air Quality

Facility managers possess an intrinsic understanding of the pivotal role played by ventilation in preserving indoor air quality, particularly in healthcare institutions such as hospitals. Ventilation within the hospital setting entails the process of exchanging ambient indoor air with fresh outdoor air to augment the quality of the indoor environment. Sustaining optimal air exchange rates becomes indispensable in upholding a salubrious indoor milieu conducive to the well-being of patients, staff, and visitors [2].

2.3. Significance of Adequate Ventilation

Three salient facets underline the significance of ventilation within hospitals to ensure superlative indoor air quality:

1. Eradication of Contaminants:

A judicious application of ventilation in hospital settings serves as a potent mechanism for expelling pernicious contaminants, including airborne viruses, bacteria, and pollutants, from the confines of indoor air. In hospitals, where airborne pathogens are known culprits in propagating infections and ailments, this undertaking holds paramount importance.

A peer-reviewed study conducted under the auspices of the National Institute for Occupational Safety and Health ascertains that the escalation of ventilation rates within hospitals correlates with a reduction in the transmission of airborne diseases and infections among both patients and the healthcare workforce [2].

2. Regulation of Humidity:

Ventilation's role in hospitals extends to the harmonization of indoor humidity levels, a factor that exerts a discernible influence on indoor air quality. Elevated humidity levels have the potential to foment the proliferation of mold, mildew, and other fungi, consequently precipitating respiratory afflictions and allergic reactions.

Research findings from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) corroborate that the judicious maintenance of humidity levels through efficacious ventilation mechanisms can redound to the amelioration of indoor air quality and the prevention of deleterious microorganism growth [3].

3. Dispelling Odors:

Effective ventilation measures assume the role of an olfactory curator, dispelling malodorous elements and engendering an atmosphere redolent of freshness. Within healthcare facilities, notably hospitals, noxious odors can be particularly distressing and have the potential to impede patient convalescence.

A study published in the Journal of the Air & Waste Management Association underscores that augmenting ventilation rates within hospitals engenders a tangible reduction in the concentration of unpleasant odors, ultimately fostering an enhancement in the overall quality of indoor air [1].

2.4. Ventilation Management in Hospitals: A Focus on Assessment and Maintenance

The maxim "we cannot manage what we don't measure" underscores the importance of initiating a comprehensive management plan for hospital ventilation, which commences with a meticulous evaluation of the HVAC system. Indeed, the very "V" in HVAC signifies the pivotal role that ventilation plays in this context. Subsequently, the data obtained from the assessment serves as the basis for prioritizing corrective actions aimed at enhancing or sustaining the HVAC system's efficiency [2].

2.4.1. Assessing the HVAC System

An HVAC conditions assessment transcends mere considerations of an air handling unit's age, make, and model. When tailored for assessing ventilation in hospitals, it encompasses a thorough investigation across the following key domains:

1. Physical Conditions
2. Performance
3. Environmental State [3].

2.4.2. HVAC Cleaning and Restoration

The attainment of compliant ventilation in hospitals hinges upon the cleanliness and proper maintenance of HVAC equipment. Adhering to the guidelines set forth by ASHRAE and the insights gleaned from HVAC conditions assessments, it becomes imperative to undertake the cleaning and restoration of equipment. This endeavor encompasses three primary service categories aimed at restoring the mechanical inventory's operational prowess:

1. HVAC Steam Cleaning
2. Environmental Duct Cleaning
3. HVAC Restoration [2].

These services complement each other to bring the entire HVAC system to an optimal state of cleanliness and performance. Beyond mere cleaning, HVAC restoration assumes a multifaceted role by re-commissioning the equipment through a combination of cleaning procedures, the application of high-performance coatings, and the integration of cutting-edge technological upgrades, such as ECM Fan Array retrofits [3].

2.5. Comprehensive Guide to HEPA Filters in Hospital Environments

The necessity for effective air filtration within medical facilities cannot be overstated. Hospitals, doctor's offices, research institutions, and dental clinics are subject to stringent regulations governing air quality to mitigate the risk of hazardous pathogens infecting individuals. Without robust air filtration, the potential for these pathogens to contaminate patients, staff, and even the broader public, thereby contributing to the spread of various diseases, remains a significant concern. In response to these imperatives, HEPA (High Efficiency Particulate Air) filters have become a staple in most medical settings [4].

2.5.1. Understanding HEPA Filters

HEPA filters represent a specific class of pleated mechanical air filters, as shown in figure (1). The acronym HEPA stands for "high-efficiency particulate air [filter]" as officially designated by the U.S. Department of Energy. These filters are engineered to remove, in theory, a minimum of 99.97% of airborne particles measuring 0.3 microns (μm) or larger. This particular size, 0.3 microns, corresponds to the most penetrating particle size (MPPS). HEPA filters exhibit even higher efficiency in capturing particles larger or smaller than this critical threshold. Therefore, the 99.97% efficiency rating applies to all particle sizes, making them a robust choice for air filtration [5].



Figure 1: HEPA Filter [5].

2.5.1.1. Functionality of HEPA Filters in Medical Environments

In medical settings, maintaining air free of harmful viruses and bacteria is paramount, particularly in surgical facilities and hospitals. HEPA filters are the trusted guardians of air quality in these contexts. Antimicrobial HEPA filters, equipped with the ability to neutralize dangerous microbes upon contact, are the preferred choice.[5] HEPA filters are strategically employed in various capacities in medical environments:

1. Surgical Suites:

The critical demand for hospitals is to safeguard the health of medical personnel and patients by effectively filtering the air in operating rooms. HEPA filters excel at removing airborne contaminants that could compromise the well-being of individuals undergoing surgical procedures. Moreover, they aid in reducing the incidence of hospital-acquired infections (HAIs), helping hospitals meet industry benchmarks and avoid associated financial penalties.

2. Incubators:

Newborns, who often possess weaker immune systems, are vulnerable to various bacteria and viruses. HEPA filters are indispensable in neonatal care units (NICUs) to ensure that the air entering incubators remains clean and free of harmful microbes.

3. Warming Beds:

Patient beds frequently incorporate HEPA filters to prevent the transmission of contaminants from warming systems to the surrounding air. Closed-circuit forced air systems within warming beds maintain patient comfort, and HEPA filters act as a crucial barrier, inhibiting the dispersion of hazardous particles.

4. Cleaning Machines:

HEPA filters, when combined with daily cleaning equipment, contribute to improved air quality within medical facilities. These filters are commonly integrated into cleaning tools like sweeper scrubbers, vacuums, and air purifiers to maintain surfaces free from microbial contamination.

5. Medical Laboratories:

Laboratories where scientists and medical professionals routinely work with dangerous pathogens rely on HEPA filters to remove airborne microbes and pathogens, mitigating the risk of contamination. Legal mandates often stipulate the use of HEPA filtration in such environments.

It's important to note that the specific type of HEPA filtration employed may vary based on the unique needs and regulatory requirements of each healthcare facility [6].

2.6. The Significance of UV Light Filtration in Healthcare Settings

While the use of HEPA filters in hospitals is commonplace, it may not always suffice to completely sterilize and decontaminate the air of dangerous microbes. Therefore, many medical facilities have turned to UV (Ultraviolet) light air filtration systems as an additional measure to effectively combat germs and bacteria. The key lies in utilizing specific UV lights, specifically germicidal light, which, when harnessed within the correct spectrum, can be instrumental in further purifying the air within medical environments [7].



Figure 2: UV Light Air Filtration System [7].

2.6.1. UV Light Air Filtration Systems

UV HEPA systems can be seamlessly integrated with a building's HVAC (Heating, Ventilation, and Air Conditioning) system. In-duct UV systems employ light to disinfect the air as it circulates through return ducts, ensuring a continuous purification process. Another variant of this system adopts a coil sterilization approach, employing UV-C lamps to target specific components such as cooling coils, filters, and condensation pans. This approach prevents microbial growth in hard-to-reach areas like seams, edges, and grooves, which are typically more challenging to access and clean [7].

Furthermore, portable UV-C air purification units can be strategically positioned in critical areas and relocated as necessary. This flexibility allows healthcare facilities to concentrate UV purification efforts in spaces where microbial control is of the utmost importance, adapting to evolving needs and priorities [7].

2.7. Definition of a Portable Air Purifier

Portable air purifiers represent filtration devices designed to purify the air by removing pathogens, viruses, bacteria, particulate matter (e.g., pollen, dander, and dust mites), and various contaminants, including VOCs. It is imperative to acknowledge that not all air purifiers exhibit identical features. Portable air cleaning systems employ diverse technologies to support different applications, with certain systems offering superior air purification capabilities compared to others [8].

2.7.1. Mechanism of Operation for Portable Air Purifiers

Portable air purifiers utilize robust and noise-efficient fans to draw in contaminated air via an intake mechanism. The air subsequently traverses through multiple stages or layers of filtration media, where it captures and reduces the concentration of airborne pollutants and contaminants. Finally, the clean air is expelled from the system and reintroduced into the indoor environment [8].

The effectiveness of portable air purifiers in delivering clean air and mitigating viral transmission hinges on several critical factors, which include:

- The types of filtration media employed, encompassing HEPA, Pre-Filters, and Activated Carbon Filters.
- The filtration media's capacity to capture airborne particulate matter and contaminants in terms of size (measured in microns) and the percentage removed.
- The incorporation of electronic air cleaning technologies, such as UV-C Lights/Photocatalytic-Oxidation Technology (PCO), Negative Ionization, and Hydroxyl Radical Technology.
- The number of air exchanges the system can provide per hour within a given space, commonly referred to as Air Exchanges Per Hour (ACH).
- The system's air delivery rate per minute, quantified in cubic feet per minute (CFM).

2.7.1.1. True HEPA Filters

HEPA Filters, a type of mechanical particulate air filter, are renowned for their ability to capture approximately 99.95% to 99.97% of airborne particles measuring 0.3 μm (microns) in size. These particles encompass allergens, dust, moisture, bacteria, viruses, dirt, and submicron liquid aerosols. HEPA filters are widely favored due to their straightforward implementation, consisting of interwoven fibers (often composed of plastic, glass, or fiberglass) that effectively trap particles. The filter's efficacy relies on the density of these fibers, typically ranging from MERV 12 to MERV 17 filters. However, it is crucial to note that not all HEPA filters are genuine. Some non-branded alternatives attempt to emulate HEPA filters but cannot guarantee

the same filtration accuracy. Therefore, it is advisable to always seek the True HEPA label when exploring portable air purifiers [5].

2.7.1.2. Activated Carbon Filters

An Activated Carbon Filter functions as an adsorbent media filter that utilizes activated carbon or charcoal, specifically engineered to possess a porous structure. The activation process of the carbon, achieved through either physical method like carbonization or chemical activation, enhances its porosity and increases the number of crevices available for carbon adsorption. This transformation makes activated carbon an exceptionally efficient filter for capturing challenging particulate matter.

In air purifier systems, Activated Carbon Filters serve as a pre-filter complementing HEPA filters. They excel at capturing harmful gases, commonly referred to as VOCs, which are implicated in various health issues, including allergies, asthma, sick building syndrome (SBS), and respiratory infections. VOCs are prevalent within office environments, arising from sources like photocopiers, building materials, and furnishings. [9]

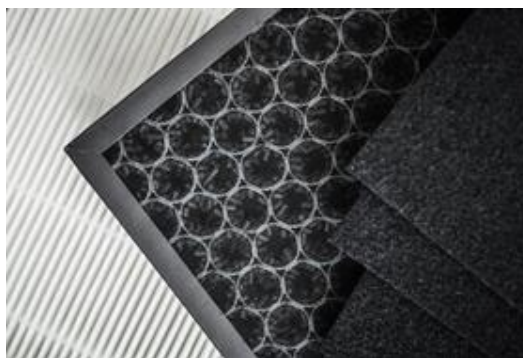


Figure 3: Carbon Filters [9].

2.7.1.3. UV-C Light, UVGI, or PCO Technology

The majority of airborne contaminants are minuscule and challenging to apprehend, encompassing viruses, bacteria, and mold. Hence, portable air purifiers frequently incorporate electronic air cleaning technologies to mitigate the presence of these harmful pathogens. Among the most prevalent technologies employed is UV-C, UVGI, or PCO Technology [10].

In the context of UVGI or PCO processes, UV-C light, also originating from the sun, is harnessed and harnessed for disinfection purposes. When applied, UV-C light can disrupt the membranes and genetic material of pathogens, viruses, and drug-resistant bacterial particles. This technology proves highly effective in curtailing the transmission of illnesses and serves as a potent disinfectant [10].

2.7.1.4. Negative Ionization

Another variant of electronic air cleaning technology is negative ionization, alternatively known as bi-polar ionization or needle-point ionization. This technology empowers portable air purifiers to attract and aggregate airborne particulate matter. In operation, ionic air purifiers electrically charged particles and ions, facilitating their capture by HEPA and Activated Carbon Filters. This capability enhances the filtration of particles, including VOCs and those smaller than 0.3 microns in size.

It is essential to note that while negative ionization offers advantages, certain manufacturers with substandard and untested systems may release ozone. Prolonged exposure to elevated ozone levels within enclosed spaces can pose health hazards. Consequently, it is imperative to ensure that the air purifier you consider or use adheres to the guidelines established by the California Air Resources Board (CARB) [11].

2.7.1.5. Hydroxyl Radical Technology:

Hydroxyl radical technology leverages the potent capabilities of hydroxyl radicals (OH⁻) to facilitate continuous and safe oxidation processes. These hydroxyl radicals interact with a wide range of pollutants and play a pivotal role in the operation of air purifiers. This innovative technology releases hydroxyl radicals into the air, enabling them to bind to pathogenic microorganisms, such as viruses and bacteria, while concurrently reducing the concentration of VOCs and particulate matter (PM) in the ambient air [12].

Notably, hydroxyl radical technology exhibits an impressive efficacy rate of 99.9% in eliminating pathogenic microorganisms. It stands out for its environmental friendliness, as it does not emit ozone, and it harnesses one of nature's fundamental oxidizing agents. Hydroxyl radicals also play a significant role in mitigating greenhouse gases, underscoring their multifaceted importance [12].

2.8. Literature Review

Indoor air pollution stands as a significant global health concern, particularly within confined spaces like hospitals, where patients with compromised immune systems and healthcare professionals spend substantial amounts of time. In recent years, the advent of portable air purification devices has emerged as a promising avenue for addressing this issue, offering a convenient and effective means of improving IAQ within hospital environments.

The deployment of portable air purification devices in hospitals often integrates advanced filtration technologies designed to capture and neutralize airborne pollutants effectively. High Efficiency Particulate Air (HEPA) filters, renowned for their ability to remove particles as small as 0.3 microns, are pivotal in mitigating airborne pathogens and allergens that pose significant risks to patients and healthcare workers alike [13]. Moreover, activated carbon filters play a complementary role in adsorbing VOCs and odors emanating from diverse sources within hospital environments, thereby addressing multiple sources of indoor air pollution [14].

Supplementary purification methods, such as UV-C sterilization, have garnered considerable attention for their efficacy in inactivating pathogens within hospital settings. UV-C irradiation disrupts the DNA structure of viruses and bacteria, offering an additional layer of defense against airborne infections in hospital wards and surgical suites.[15] Integrating UV-C sterilization with traditional filtration systems bolsters the overall purification efficacy, contributing to the maintenance of clean and sterile air crucial for patient recovery and infection control.

Recent technological advancements have led to the integration of smart sensors in portable air purification devices, facilitating real-time monitoring of key air quality parameters. These sensors measure particulate matter (PM) levels, VOC concentrations, and humidity, allowing for the automatic adjustment of purification settings based on detected pollutants. [16] Such smart features not only enhance user convenience but also ensure optimal IAQ management, essential for safeguarding patient health and well-being.

Energy efficiency emerges as a paramount consideration in the design of portable air purification devices for hospitals, where operational costs and environmental impact are critical factors. Models equipped with low-power consumption and energy-saving features offer sustainable solutions without compromising performance, contributing to long-term cost savings and environmental sustainability efforts within healthcare facilities [17].

The compact and lightweight design of portable air purifiers is another notable feature, allowing for seamless integration into existing hospital infrastructure. Ergonomic features and convenient carrying handles facilitate easy relocation and deployment in critical areas such as patient rooms, intensive care units, and operating theaters [18]. Furthermore, advanced noise reduction technology ensures quiet operation, minimizing disruption to patient care and staff productivity in hospital environments where a conducive healing environment is paramount [19].

Numerous studies have underscored the positive impact of portable air purification devices on IAQ and occupant health within hospital settings. Users report reduced symptoms of allergies and respiratory ailments, improved sleep quality, and enhanced overall well-being following the implementation of air purifiers in healthcare facilities. [20] Such findings underscore the critical role of portable air purification devices in promoting patient recovery and ensuring a safe and healthy hospital environment.

In conclusion, the deployment of portable air purification devices represents a promising strategy for enhancing IAQ and mitigating indoor air pollutants within hospital environments. Further research and development efforts are warranted to optimize the design and operation of these devices, ultimately contributing to improved patient outcomes and fostering a healthier healing environment in hospitals globally.

Chapter Three

Experimental Part

3.1. Introduction

The concept of air purification dates back to the mid-20th century, with early devices employing basic filters to capture large particles and dust. In the 1940s, the introduction of HEPA filters marked a significant advancement, allowing for the capture of smaller particles such as allergens and bacteria. However, it wasn't until the 1960s and 1970s that ozone generators were incorporated into air purifiers to neutralize odors and eliminate airborne bacteria. Concerns about elevated ozone levels led to a shift away from these devices.

In the 1970s and 1980s, electronic air purifiers gained popularity, utilizing electrostatic precipitators to charge particles and make them adhere to collector plates. Despite their effectiveness, these devices required regular maintenance. The 1990s saw the integration of Ultraviolet-C (UV-C) light technology, known for its ability to kill bacteria and viruses. The early 2000s brought the use of activated carbon filters, enabling air purifiers to adsorb gases, odors, and VOCs.

Advancements continued into the 2010s and beyond, with the incorporation of smart features in air purifiers, such as the ability to monitor air quality and adjust settings remotely through mobile apps. Ongoing developments in filtration technology led to the creation of multi-stage filtration systems, combining HEPA filters, activated carbon filters, and other specialized filters to target specific pollutants. Modern portable air purifiers are designed to be compact, lightweight, and easily portable, suitable for a variety of settings. Some of the latest models include air quality sensors and artificial intelligence algorithms, allowing them to automatically adjust settings based on real-time air quality data. The evolution of portable air purifiers reflects a continual effort to enhance efficiency, versatility, and user-friendliness in providing cleaner indoor air.

3.2. Portable Air Purifiers

Portable air purifiers represent filtration devices designed to purify the air by removing pathogens, viruses, bacteria, particulate matter (e.g., pollen, dander, and dust mites), and various contaminants, including VOCs. It is imperative to acknowledge that not all air purifiers exhibit identical features. Portable air cleaning systems employ diverse technologies to support different applications, with certain systems offering superior air purification capabilities compared to others.

3.3. Portable Air Purifiers Components

3.3.1. Box

- The box has been designed and manually crafted with specific dimensions using aluminum as the material as shown in figure (4). Aluminum was chosen for its electrical insulation properties, aiming to avoid electrical shock in case of a leakage. Additionally, it is a

lightweight and durable material, making it suitable for carrying the device components while maintaining their integrity.

- The box features two openings: the first one contains a filter, serving as an inlet for air laden with dust, airborne particles, and viruses. The second opening is for the exit of purified and sterilized air after filtration.



Figure 4: The Aluminum Box.

3.3.2. Air Filter

An air filter is a component that removes unwanted particles from the air as shown in figure (5). It's like a net that catches spray, dust, particles, and other pollutants. The effectiveness of an air filter is typically measured by its filtration efficiency and ability to capture particles of different sizes. Regular replacement or cleaning of air filters is essential for maintaining optimal performance.



Figure 5: Air Filter.

3.3.3. Power Transformer

An AC-to-AC adapter is a power transformer that steps down the voltage of an alternating current at a specific frequency from a mains power supply. It is used for transforming AC power to supply a load requiring lower voltages as shown in figure (6).



Figure 6: AC to AC Powers Transformer.

3.3.4. Rectifier

A rectifier is an electronic device that converts an alternating current into a direct current by using one or more P-N junction diodes as shown in figure (7). A diode behaves as a one-way valve that allows current to flow in a single direction.



Figure 7: Rectifier.

3.3.5. Capacitor

A capacitor is a binary-terminal electrical apparatus capable of accumulating energy in the manifestation of an electric charge. It is composed of two electrical conductors spatially isolated from each other as shown in figure (8).

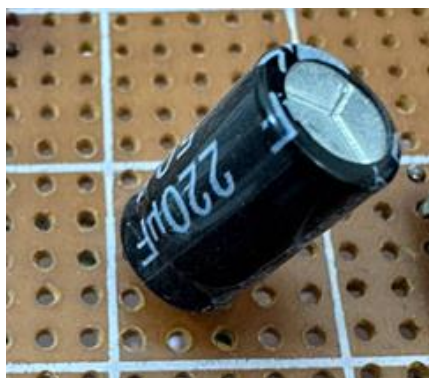


Figure 8: Capacitor.

3.3.6. LED

A Light-Emitting Diode (LED) is a semiconductor device that emits light when an electric current is applied to it. This illumination is a result of the recombination of electron-hole pairs within the semiconductor material, leading to the release of photons. LEDs are characterized by

their efficiency, durability, and compact size, making them a prevalent and energy-efficient lighting source across various applications as shown in figure (9).

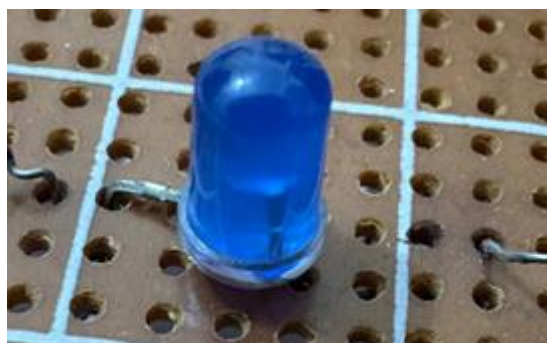


Figure 9: LED.

3.3.7. Resistance

Resistance, in the context of electrical circuits, is a fundamental property that impedes the flow of electric current. It is measured in ohms (Ω) and is contingent upon the material, dimensions, and temperature of the conductor. Essentially, resistance signifies the degree to which a material hinders the passage of electrons, converting electrical energy into heat as a byproduct. This inherent opposition to current flow is a pivotal parameter in the design and analysis of electrical circuits, influencing their performance and behavior as shown in figure (10).

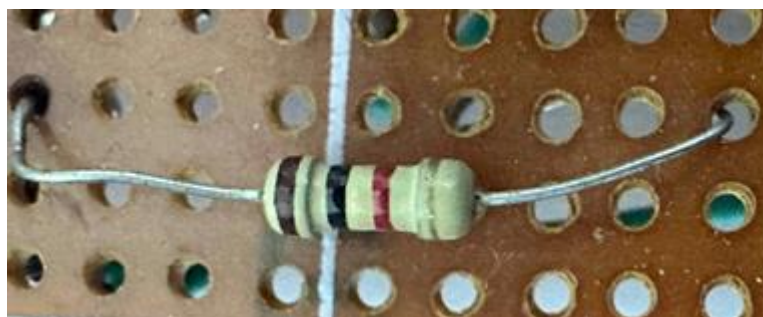


Figure 10: Resistance.

3.3.8. UV Sterilization System

An ultraviolet (UV) system for air sterilization is a technology that uses ultraviolet light in the germicidal range to eliminate or deactivate microorganisms, such as bacteria and viruses, present in the air as shown in figure (11). This system disrupts the DNA and RNA of pathogens, preventing their replication and thereby contributing to improved indoor air quality and reduced transmission of infectious agents. UV systems are commonly employed in settings where maintaining a sterile environment is crucial, such as healthcare facilities and laboratories.



Figure 11: UV Sterilization System.

3.3.9. Fan

A minimized fan refers to a compact and space-efficient fan design that has been streamlined or optimized for reduced dimensions while maintaining its core functionality as shown in figure (12). Such fans are engineered to occupy minimal physical space while providing sufficient airflow or cooling capabilities. Minimized fans find applications in environments where spatial constraints or design aesthetics necessitate compact solutions, such as in electronic devices, small appliances, or other systems where efficient air circulation or cooling is required within limited space parameters.



Figure 12: Fan.

3.4. Working Principles

- For the purpose of configuring the device for our project, it is necessary to provide a dedicated box. Therefore, we have adopted a box made of aluminum with specific dimensions that align with the design, materials used, and the intended purpose.
- Following that, we design a card equipped with a power output of 12V DC, compatible with the power requirements of the fan used to introduce air for sterilization. The power supply we have prepared reduces the voltage from 220V AC to 12V AC, and since the fan operates on DC only, we will use an electronic component called a rectifier with the card to convert the current from AC to DC, aligning with the fan's operation.
- After obtaining the required voltage, it is necessary to filter and smooth this voltage using a capacitor with a suitable value (25V). Following voltage filtering, we must stabilize the voltage at this level. Therefore, we use a voltage regulator set at 12V.
- With the power supply card, we use one LED with two resistances with value of 1k ohm each. The purpose is to create a voltage divider suitable for the LED voltage. Placing the LED within the card serves the purpose of verifying that the card is functioning without issues.
- For the purpose of air sterilization, two ultraviolet systems are employed. The goal is to eliminate viruses in the air by affecting the DNA within these viruses through the breakdown of DNA strands using high-frequency ultraviolet waves with wavelengths ranging from 280 to 350 nanometers. These high-frequency waves are intolerable to viruses in the air.
- Filters are used inside the device, positioned in front of the fan. The purpose of these filters is to trap spray, dust, and particles present in the air, especially in hospital environments.

Chapter Four

Discussions

The Air Purification device has two stages:

1- Filter:

The function of the filter in the device is to enhance indoor air quality by capturing airborne particles such as dust, dirt, insects, and other particles and pollutants that could exist in the ambient air as it passes through it. These pollutants cause and aggravate respiratory illnesses, skin disorders, allergies, and other illnesses.

2- UV Light

UV (ultraviolet) light is a powerful tool for air purification due to its ability to disinfect and deactivate microorganisms such as bacteria, viruses, and mold spores. UV air purification systems work by using UV light. Therefore, a UV generator has been installed after the filter to capture these microorganisms that pass through the filter. UV (ultraviolet) light is a type of electromagnetic radiation that has short wavelengths and high energy. It is divided into several subcategories based on wavelength:

1. UV-A (320-400 nm)
2. UV-B (280-320 nm)
3. UV-C (200-280 nm)

The last type of UV light is the most energetic and germicidal type of UV radiation. It is highly effective at destroying the DNA and RNA of microorganisms like bacteria, viruses, and molds, making it a powerful disinfection tool and hence it is highly effective in air purification.

In air purification device, there are typically three main speed settings for the fan. These settings allow users to control the airflow and noise level of the device according to their preferences and the air purification needs of their environment. Here's an overview of the three speed settings:

1. **Low Speed:** The low-speed setting is characterized by a gentle airflow and minimal noise output. It is suitable for situations where quiet operation is desired, such as during sleep or in quiet environments like bedrooms or offices. While the airflow may be lower compared to higher speed settings, it still provides effective air purification over time.
2. **Medium Speed:** The medium-speed setting offers a moderate airflow and slightly increased noise compared to the low-speed setting. It provides a balance between airflow and noise level, making it suitable for general use in various indoor environments. Medium speed is often chosen for everyday air purification needs, as it provides a good compromise between efficiency and noise.
3. **High Speed:** The high-speed setting delivers the maximum airflow and may produce more noticeable noise compared to the lower speed settings. It is typically used when rapid air purification is needed, such as during periods of high pollution or when there are strong odors or allergens present in the air. High speed can quickly improve indoor air quality but may be louder and consume more energy than lower speed settings.

Chapter Five

Conclusions and Recommendation

5.1. Conclusions

From the designed board of the present study, it can be concluded that:

1. The portable air purification device implemented successfully by using simple and low costs tools.

2. The portable air purification device demonstrated effective removal of airborne pollutants environment.
3. The portable air purification device characterized compact and lightweight design facilitated easy transportability, allowing users to purify air in various environments.
4. The portable air purification device offered user-friendly operation and maintain.
5. The portable air purification device offered efficient filtration technology by using Ultraviolet light.

5.2. Recommendations

1. Optimize the performance of the device by incorporating advanced filtration technologies, such as high efficiency particulate air (HEPA) filters and activated carbon filters, ensured efficient removal of contaminants from the air.
2. Add sensor to measure the amount of viruses for comparison purposes by feedback process.
3. Identify new materials and manufacturing techniques to reduce device size and weight.

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