



e-ISSN: 2278-8875

p-ISSN: 2320-3765

# International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

Volume 11, Issue 3, March 2022

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 7.282

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☑ 6381 907 438

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# Standalone Solar-Powered Ultraviolet Mobile Disinfectant: Bringing Solar Energy in the Global Fight against COVID-19

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**ABSTRACT:**As the first initiative of its kind in Algeria, here is presented a solar-powered mobile “Ultraviolet Germicidal Irradiation” disinfection unit (UVGI) based on a special germicidal ultraviolet-C (UVC) radiator. The system was designed to disinfect several objects such as: medical tools, reusable masks, face-shields, gloves, phones, laptops, keys, money and many other portable devices that need to be disinfected/sterilized. It offers the advantage of complete autonomy through the built-in photovoltaic (PV) system that includes a solar panel, a gel battery, a charge controller and a power inverter. The system provides an extra 220V-50Hz outlet with 375VA maximum power to be used when energy is needed. The system is easily scalable to generate higher ultraviolet dosages by adding more UVC lamps. The chemical-free germicidal UVC sanitizing method employed by this device effectively deactivates a very wide range of microorganisms (microbes bacteria and fungi and viruses including the actual SARS-CoV-2 that causes COVID-19 respiratory disease) and it has several advantages in comparison to chemical-based sanitizing methods. The total cost to make this open source device is below 1000 € and is easily customizable and scalable. This device is an open source, secure and fast equipment for objects and surface disinfection. The device will be fully automated by adding PIR sensors or remote control after further funding will be received.

**KEYWORDS:**Solar energy, photovoltaics, UVGI, UVC, COVID-19, coronavirus, SARS-CoV-2.

## I.INTRODUCTION

The global struggle and fight against the actual pandemic caused by the rapid spread of the SARS- COV-2 coronavirus that causes COVID-19 disease is endorsed by every possible scientific, medical and technical advance humanity have ever achieved. Governments worldwide are counting on both prevention and treatment aspects in order to slow the spread of the coronavirus on one hand, and on the other hand, funds and subsidies from private and public sectors are mobilized to support the revived research and development in the quest for an effective vaccine that could save us from such a virulent pandemic. For example, artificial intelligence is exploited to predict and simulate every possible chemical formula that can be used to reach the vaccine slowdown the spread of the coronavirus has been discovered by AI and reported [1] [2]. Robotics other tasks in the same objective [3]. Many university groups and scientific clubs in Algeria are fabricating face-shields, masks, hand sanitizers, disinfection corridors, and many other equipment that are distributed to the hospitals in order to help the medical staff to fight the pandemic For example, the “WE ALGERIANS” initiative has already delivered thousands of face masks and shields to hospitals and many of its sub-teams are fabricating medical ventilators. 3D-printers as another example have allowed the innovation of many devices such as artificial respirators and ventilators, flexible face shields, reusable masks and other devices. During this week, the Algerian government has issued new laws and directives imposing wearing masks for all citizens, as a consequence, shortages of this medical masks are likely predicted, therefore, our device will help solving this problem where using a chemical-free sterilizing process would be beneficial to quickly sterilize these masks within seconds while avoiding the use of wet chemical disinfectants that may cause skin irritations and allergies. Many other reusable devices will as well need such a quick and safe physical sterilization.

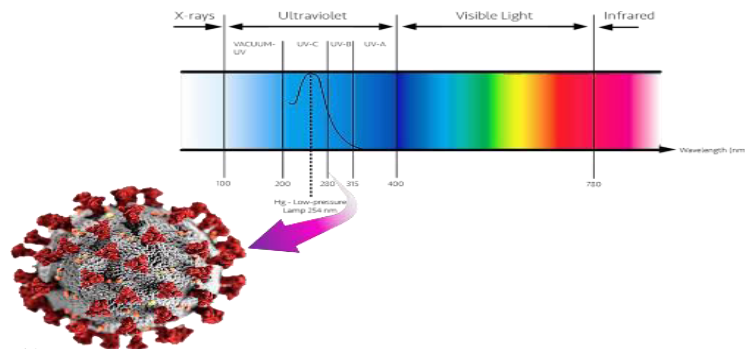


Fig.1. UVC range that is appropriate for SARS-COV-2 coronavirus.

Ultraviolet germicidal irradiation (UVGI) is a well-known chemical-free disinfection process, often defined as the use of the third ultraviolet range, namely UVC (which have wavelength within the germicidal range ( $\lambda=200\text{--}280$  nm)) for air and surfaces disinfection, see Fig.1. UVC radiation has the power to deactivate microorganisms such as microbes, bacteria, fungi and viruses (including the actual SARS-CoV-2 responsible of COVID-19) by causing DNA damage and preventing their replication [4]. Historically, the term ‘UVGI’ was originally coined by the International Commission on Illumination (CIE) and adopted later by the Centres for Disease Control (CDC), and this term distinguishes disinfection applications from the nongermicidal UVA wavelengths of black lights and suntan lamps (320–400 nm). UVGI is also used to distinguish air and surface disinfection applications from those in water. The full history and timeline of UVGI development has been detailed by Wladyslaw Kowalski [4]. Recently, several studies have shown that UVC can deactivate coronaviruses, including severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV). It was also reported in a recent study that the actual SARS-CoV-2 was effectively deactivated by higher doses of UVC [5, 6]. In this work, we have designed and fabricated a mobile stand-alone photovoltaic system that carries one 36W UVC disinfection lamp which will be delivered to a local hospital as a prototype. The device joints the advantages of using abundant solar energy and UVGI disinfection capabilities. The system provides an extra amount of electrical power that can for example charge other mobile devices or supply other disinfection corridors that spray special chemicals often placed at the entrance of hospitals or medical care houses, or where electricity is not all the time available (cases of far sites, emergency or blackout).

## II. HARDWARE DESCRIPTION

The stand-alone photovoltaic system includes a 160Wp polycrystalline silicon solar panel (JONSOL, Germany), a PWM charge controller with 10A nominal current (STECA, Germany), a solar power inverter with 12V input voltage and 220V-50Hz output pure sine wave signal with a nominal power of 375VA (VICTRON Energy, The Netherlands). The battery is a sealed Gel- VRLA (valve regulated lead acid) typewith 12V voltage and 100Ah capacity (1200Wh energy) (JARRET, China). The solar panel support is 23° inclined, the whole frame consists of PV panelsupport and the back part includes small room for the battery and the inverter to be included in, this cavity is well aired as the bottom consists of a solid stainless-steel fence, the upper part integrates a cavity that contains the UVC radiator. The charge controller is fixed on the outer side of the box in order to allow constant monitoring of the battery level and the charging flow status An extra AC waterproof outlet is fixed beneath the charge controller that provides extra power from the inverter. The UVC radiator is simply controlled by switch fixed on the outer right side of the device. This will be developed in the future and replaced by a PIR detector to allow a fully automatic well-timed control. For security a DC switch is placed between the solar panel and the charge controller, and an AC switch is placed between the power inverter and the devices it supplies (radiator and the outlet). The inverter has its own protective DC fuse. The construction of the device is somehow simple and includes two main steps: metallic scaffolding construction and electrical assembly.

**UVC RADIATOR:** Here, we have used a commercial UV-C radiator that contains built-in power supply (ballast) which have a programmable timer in order to set the required disinfection time, and one quartz low-pressure mercury lamp to produce UV-C radiation (Germany). Figure.2 shows the actual used radiator. This tube provides 36W of power and can be acquired separately in the case of scaffolding can be used, the first one is to have it



attached to replacement or can be used in other devices as well. The radiator is built as one stainless steel case that have a door used to protect the lamp after usage. Two ways to fix the UVC radiator into the e facing wall where the UV rays are emitted to the outside. The second one (which we adopted) is to attach the radiator into the upper side of the UVC box in a way to have the UV rays emitted towards the bottom plate, this is way safer and well adapted to attack the treated surface directly.



Fig 2 :The used UV radiator having a 36W quartz UVC lamp.

## II. THE PHOTOVOLTAIC SYSTEM

The UVC lamp has 36W nominal power, if we assume around 8 operation hours per day that means that the required energy is  $E_{tot} = 36 \times 8 = 288$  Wh. The battery of 100Ah capacity delivers  $E_{batt} = 12V \times 100Ah = 1200Wh$  of energy which is largely sufficient for UVGI disinfection for several hours (at least 30h) without recharging. However, the system has been sized to deliver an extra amount of energy when needed. The VRLA-Gel battery will be not deeply discharged. With a 160Wp panel, to recharge a completely empty battery around 8 hours are needed ( $160 \text{ Wp} \times 8h = 1280 \text{ Wh}$ ), if the battery is partially discharged, let's say 50%, then only four hours are sufficient for full charging. The metallic frame of the device is designed in such a way that the solar panel is inclined by  $23^\circ$  deg, and that is not an ideal tilting angle for the southern part of Algeria (Laghouat city) which has  $33^\circ$  deg of latitude angle, colourful paint was applied. Trolley wheels are soldered to allow the mobility of the device. Figure.3 illustrates the simplified wiring diagram however, since the system is mobile, sun can be tracked manually, the design will be improved in the next design. The framework is built with 2mm thick steel and painted with a special anti-rust paint to resist against corrosion and humidity

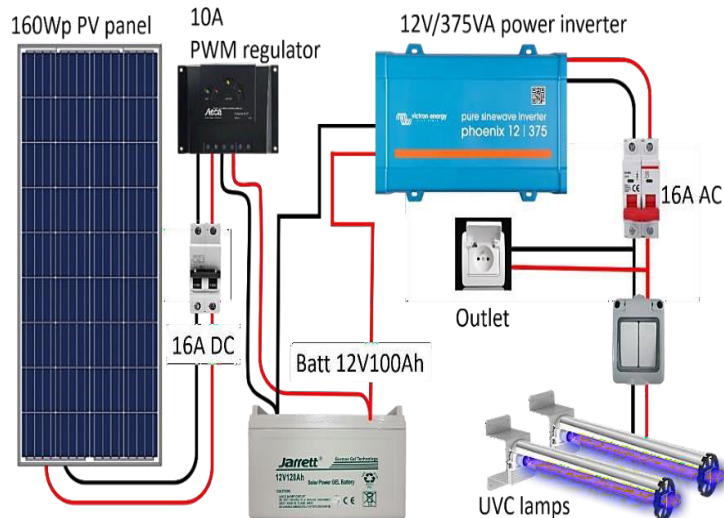


Fig 3: simplified wiring diagram of the Pv-powered UVD disinfection device.



### III. OPERATION

The mobile device was tested to disinfect several objects such as face shields and masks, smartphones and medical tools. The operation is made easy by a simple On/Off switch for several seconds according to recommendations by. Figures.4(a) and 4(b) illustrate the 3-d model of the unit along two different view angles with the respective dimensions. Figure.5 shows the unfinished system that is still under construction (will be updated later). The charge and discharge cycles were perfectly working the extra outlet was tested by plugging a powerful LED floodlight of 300W plus charging a smartphone with 18W fast charger.



Fig 4. Outlook disinfecting device



Fig 5. Complete device with setup

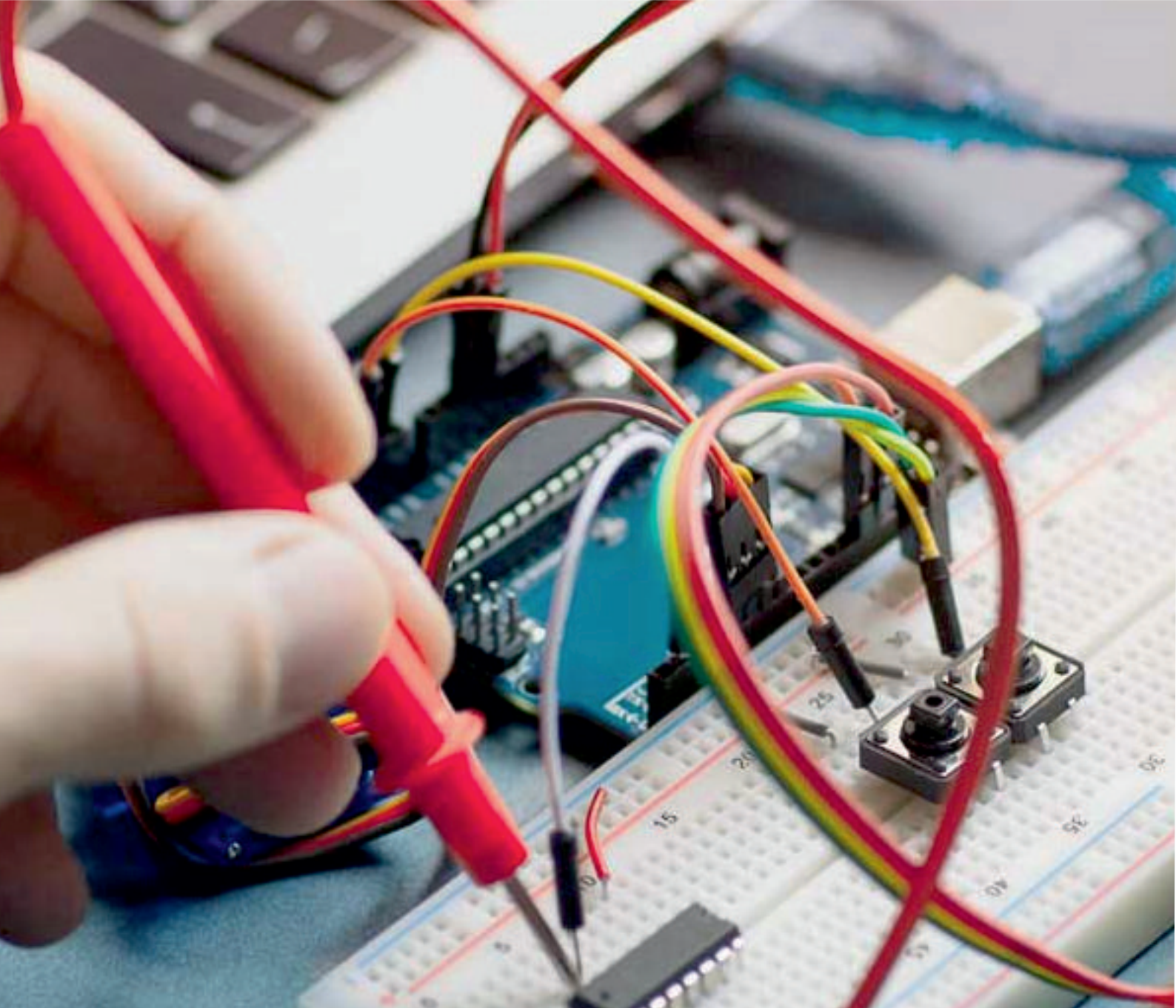
### VI.CONCLUSION

In this work, a standalone PV-powered UVC disinfectant device was conceived and constructed in the aim of bringing solar photovoltaic energy into the fight against COVID-19 pandemic. Our device is simple to build and easily movable, it can be used for hospitals entrances (indoor and outdoor), it can also be used in other places as needed to provide concise and efficient chemical- free disinfection. The device will be further developed by an automatic control of the UVC lamps through PIR sensors, and should be further supplied with microcontrollers to allow remote Wi-Fi or Bluetooth monitoring and control. We hope that this work will contribute to the global fight against COVID-19 by at least the available knowledge and materials.



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**INNO SPACE**  
SJIF Scientific Journal Impact Factor  
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