

Development of Automated Disinfection Chamber for Curtailing Spread of COVID-19

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Abstract: Corona virus disease (COVID-19) has claimed more lives in recent times than any other known disease. It is a pandemic that the World is battling. Observation of precautionary measures remains one of the strongest means of curtailing the spread of the disease. These measures include social distancing, use of face mask and personal protective equipment, as well as proper sanitization with recommended disinfectant or sanitiser. This work, therefore, delves into the development of a disinfection chamber for spraying sanitiser liquid to the human body and large surfaces as well as parts infected with the virus via pump-nozzle. The chamber is 7ft tall and is made of wood and aluminium. The electronic part of the disinfection chamber comprises an infrared sensor for detecting the presence of humans in the chamber, PIC16F72 microcontroller which sends a signal to DC pump via the output relay for releasing the sanitiser for five seconds, and power supply unit which provides the required D.C supply to power the circuit. The performance test shows the disinfection chamber is functional and releases the sanitizing liquid for five seconds after which it cuts off to await the entrance of another person. The device is recommended for use in hospitals, campuses, offices, and so on.

Keywords: COVID-19, infrared sensor, microcontroller, relay, sanitizer, symptoms

I. Introduction

Corona virus disease (COVID-19) broke out in Wuhan, China in 2019 and it has spread to all the continents in the World. It is caused by a virus known as SAR-CoV-2. Reports from various media outlets claim that over seven million people have lost their lives as a result of complications from the disease and about forty-nine million, four hundred thousand (49,400,000) active cases have been recorded worldwide. It spreads from humans to humans via close contamination with infected droplets or close association with infected persons [1, 2]. Symptoms include fever, persistent sneezing, dry cough, respiratory shortages, and difficulty in breathing [3, 4]. Recently, the second wave of the spread of the disease has been pronounced in many parts of the World [5]. Hence, there is no end in sight to the dreaded disease. Safety

measures for curtailing the spread of the disease and flattening the rising curve include social distancing, use of face mask or wearing personal protective equipment (PPE), increased personal hygiene [6], and self-isolation. Others include disinfection with appropriate and recommended disinfectant, Ultraviolet Sanitization [7]. Sanitisers or disinfectants may be applied using the hand which is most common or the use of a machine. On the other hand, works that provide insightful approaches to how the machine may be developed and deployed for dispensing sanitiser liquid are therefore limited in the literature. Few publications, reported in the literature largely employ ultraviolet (UV) lamps to construct sanitizing devices. These include [8], which designed and implemented a germicidal UVC-LED lamp for disinfection. On the other hand, [9] designed a disinfectant wrist band wearable on hand for the purpose of sanitization using radiations from UV lamps. The device is powered by either movement of the user's hand or solar cells. Two way disinfection models were implemented elsewhere [10] [11], wherein, one was made possible by the use of a disinfectant sprayer while the other utilized ultraviolet

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rays. In [12], Mahamedi and Mahamedi (2020), developed an ultraviolet germicidal irradiation disinfection unit powered by solar energy. Prolonged exposure to UV radiations is no doubt harmful to the eyes and skin and may not be the best form of disinfecting the human body. This work, therefore, focuses on the development of a disinfection machine for spraying sanitisers over the surface or human body. The machine is not harmful in any form to parts of the body and promises to reduce the stress involved in the manual dispensation of sanitisers as well as helps in curtailing the spread of COVID-19 in campuses, hospitals, and places of worship. The rest of the paper is described in what follows. Section 2 describes the material and methods adopted in the design while section 3 focuses on the tests and results carried out while section 4 is the concluding remark.

II. Materials and Methods

The block diagram used for the design of the disinfection chamber is depicted in Figure 1. It consists of an infrared sensor, power supply unit, microcontroller unit, output relay and D.C pump. Each is described as follows.

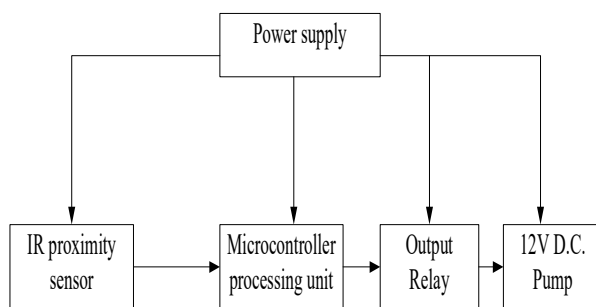


Figure 1: Block diagram of disinfection system

A. Infrared (IR) Proximity Sensor

This utilizes infra-red technology to detect the presence of the human body in the sanitization chamber. It consists of an infrared emitter and receiver. When powered on, the sensor keeps its output pin continuously high and the infrared emitter continuously emits infrared light when it detects the presence of an object.

B. Power Supply Unit

This part supplies the required DC voltage to power the circuit. Figure 2 consists of two power supply units with two bridge rectifiers, mainly for the purpose of rectifying the ac input supplied from two 9-0-9 transformers and converts it to an equivalent DC output. Figure 2(a) is the first power supply unit, filtered by 470 μ F capacitor and serves as input to 7805 and 7812 voltage regulators; both belong to a class of 78XX regulators. The 7805 regulator regulates the filtered output of the rectifier to 5V necessary to power the proximity sensor and microcontroller unit while the 7812 regulator regulates the rectifier output to 12V necessary to drive the relay. The 0.1 μ F capacitors at the outputs of the regulators prevent the regulators from going into oscillation. The output of the voltage rectifier is determined by using:

$$V_{d.c} = \frac{2V_{r.m.s} \times \sqrt{2}}{\pi} - k \quad (1)$$

wherein $V_{d.c}$ is the output of the rectifier, $V_{r.m.s}$ is the root mean square voltage and k is the voltage drop due to the diodes

Using $V_{r.m.s} = 18V$, and $k = 1.4$ in equation (1), output of voltage rectifier $V_{d.c}$ therefore becomes 16.20V .

It is well known that the maximum input voltage for 78XX regulators is 24V and the input voltage must be at least 3V above the expected output voltage, hence the condition for using 78XX regulators is satisfied in the design.

Figure 2(b) shows the second power supply unit utilized to drive the D.C. pump. The bridge rectifier output is filtered by 470 μ F capacitor.

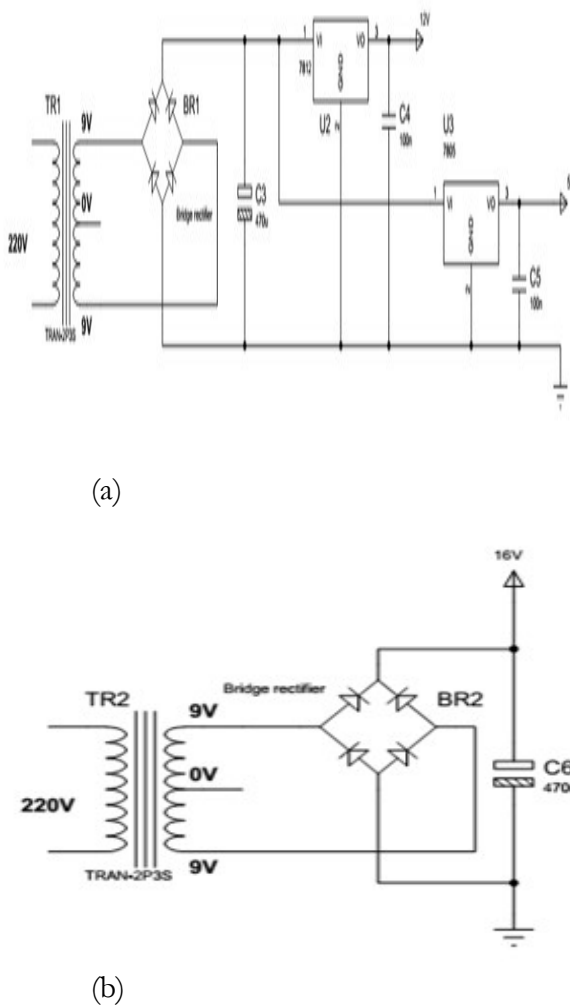


Figure 2: Power Supply for driving (a) 7805 and 7812 voltage regulators, (b) D.C pump

C. Microcontroller Unit

This unit determines the duration for which the sanitizing liquid is dispensed. PIC16F72 Microcontroller is utilized in this work which is programmed using Assembly language. It reads the output of the proximity sensor through one of its pins and also sends out an output through another pin to control the output relay which in turn controls the pump. The flow chart of the program written on the microcontroller is depicted in figure 3.

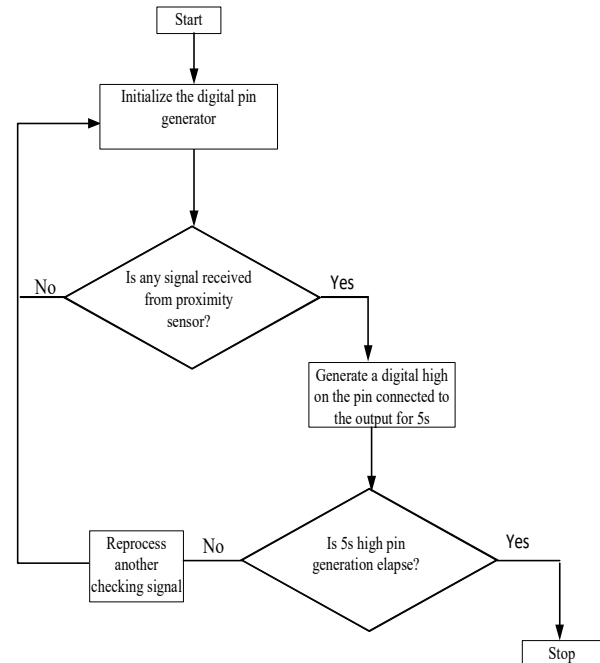


Figure 3: Flow Chart of Microcontroller program

D. Output Relay

This is an interface between the microcontroller and the DC pump. The output generated by the microcontroller is not enough to meet both the voltage and current requirement to directly drive the DC pump, hence the need for a relay. The circuit diagram of the relay section is illustrated in figure 4.

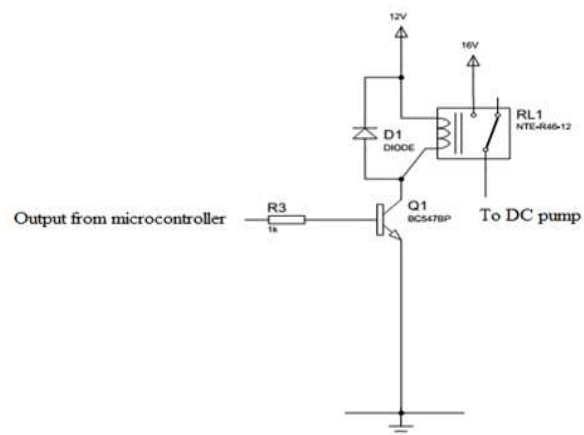


Figure 4: Output Relay

Voltage at the base of the transistor (V_b) when there is a high output from the microcontroller, is 5V, and the resistance in the base circuit (R_b) is $1k\Omega$.

Therefore base current that flows in the circuit denoted by I_b , is expressed by

$$I_b = \frac{V_b}{R_b} = \frac{5}{1000} = 5mA \quad (2)$$

At saturation, the current flowing in the collector circuit, I_c is determined using:

$$I_c = \frac{V-0.2}{R_c} = \frac{12-0.2}{330} = 35.75mA \quad (3)$$

in which R_c is the resistance of the relay in the collector circuit

The base current required to cause saturation denoted by I_k emerges from

$$I_k = \frac{I_c}{h_{fe}} = \frac{35.75 \times 10^{-3}}{110} = 0.325mA \quad (4)$$

in which h_{fe} represents the dynamic value of common emitter current gain of transistor (BC547).

Since the actual current that is flowing through the base of the transistor is higher than that required for saturation, the relay will be latched on whenever the microcontroller outputs a digital high on the pin to which it is connected via the transistor and resistor.

E. D.C. Pump

The DC pump used in this work is a windshield washer pump usually found in cars for pumping water unto the windshield for a quick wash by the wiper. This pump is inexpensive and when placed in the proper position, it can generate enough pressure to dispense the sanitiser liquid.

F. Working Principle of Sanitizer Chamber

The IR proximity sensor detects the presence of a person inside the sanitization chamber and sends a signal to the microcontroller unit to alert it of the situation. The microcontroller

on receiving the signal outputs a high which is in turn used to drive the relay output that powers the DC pump for releasing the sanitizing liquid through the nozzles to the body of the person. The microcontroller cuts out the output after 5s to stop the pumping of the sanitizing liquid until another person steps in. Figure 5, therefore, shows the full circuit diagram of the electronic part of the disinfection chamber.

III. Results and Discussion

Figure 6 depicts the electronic part of the disinfection chamber, constructed based on the circuit diagram shown in Figure. 5. Figure 6(a) shows an internal feature of the electronic control part while figure 6(b) encloses the internal mechanisms of disinfection system in PVC container. At each stage of the design implementation, a multi-meter is used to ascertain that each stage is fed with the required voltage. Five persons were selected for testing the performance of sanitizing chamber. It was found that the system discharges the sanitizing liquid to the body for 5s. It is however found that IR proximity sensor reacts to daylight. This is attributed to the fact that daylight contains some elements of infrared radiation. This challenge is solved by adjusting the sensitivity of the sensor and also using a black plastic cylindrical pipe to shield the IR receiver of the sensor from surrounding daylight. This remained so for all the evaluation performance carried on the disinfection chamber. Other tests carried out reveal that when the sanitiser container is not placed high enough, it may be impossible to generate pressure to force the liquid out of the mist nozzles to form a mist and it may also be impossible to control the release of the sanitiser liquid as gravity takes over and keeps pushing the sanitizing liquid out even after the electronic control system has cut off the control signal. Figure 7 portrays a working sanitization chamber which releases disinfection liquid for five seconds and cut off to await the entrance of another person.

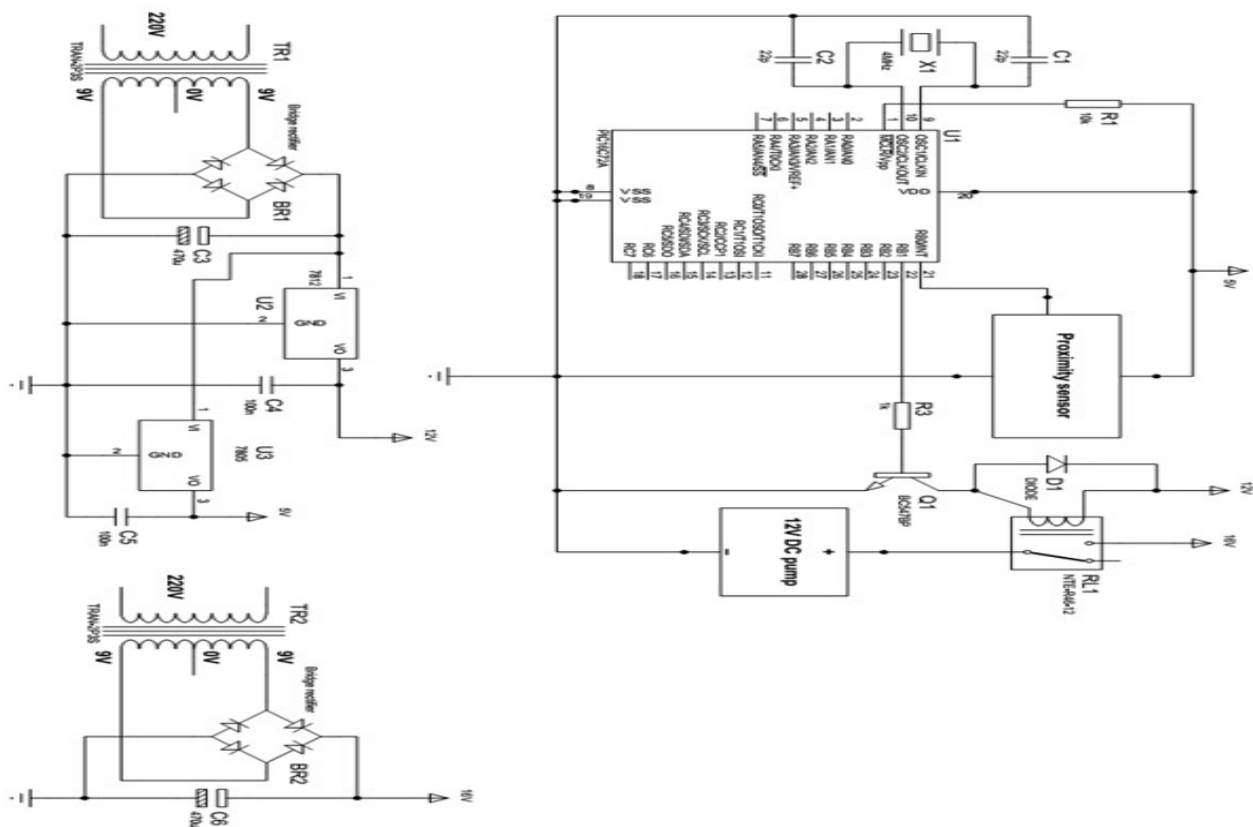


Figure 5: Circuit diagram of disinfection system

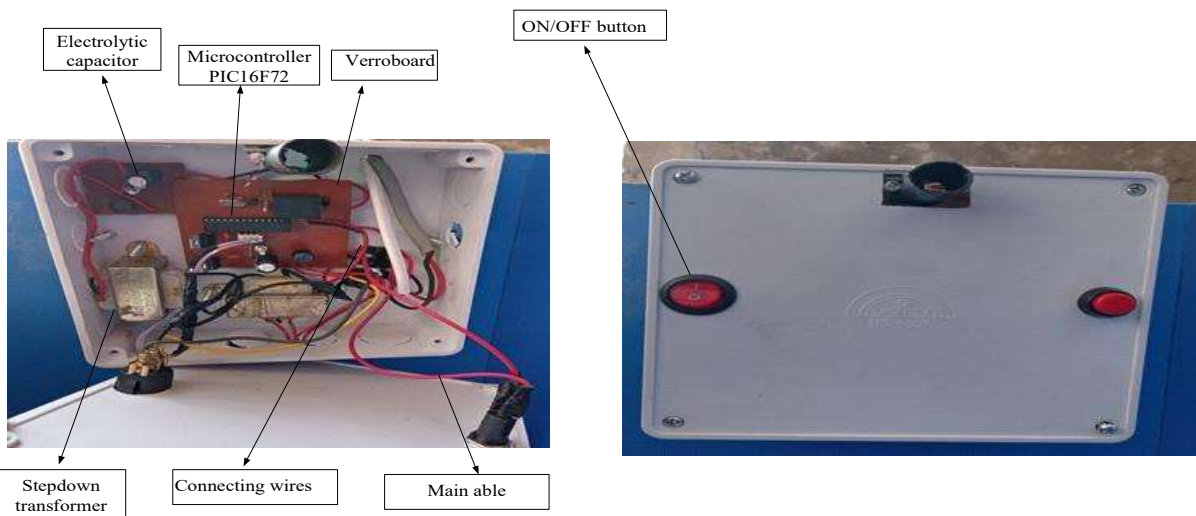


Figure 6: Constructed device, (a) internal feature of disinfection system, (b) automated disinfection system enclosed in a PVC container.



Figure 7: Pictorial illustration of sanitization chamber

IV. Conclusion

As the World continues to witness a surge in COVID-19 cases, there is an urgent need to strictly observe safety measures more than ever before. These safety precautions seem to be the leeway for stemming the spread of the disease as the production of vaccines for treating the disease is at the lowest ebb. It is in that regard that this work focuses on developing a disinfectant chamber for sanitizing the body and surfaces. The chamber which is 7ft tall and is made of wood and aluminium. The disinfection system comprises an infrared sensor for detecting the presence of a human body, a microcontroller unit for sending the signal to D.C pump through the output relay for releasing the sanitizing liquid for five seconds and cuts off after expiration of the time. The chamber is powered by power supply unit. The system promises to reduce the stress involved in the manual dispensation of sanitiser and may help in controlling the spread of disease in hospitals, schools, banks, and offices.

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