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Design and Build a Sterilization Tool Using Arduino Based Ultraviolet C Light

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Abstract — This study aims to determine the effectiveness of ultraviolet C light in sterilizing everyday objects. Arduino MKR WiFi 1010 is used as a processing device, UVGI lamp, 16×2 LCD, and a stepper motor controlled by the A4988 driver as an output device. Users can use this tool without direct touch because it uses an Infrared Proximity Sensor and an HC-SR04 Ultrasonic Sensor as input devices so that they can minimize the spread of microorganisms through physical contact with objects, especially during the current Covid-19 pandemic. In this study they used research and development methods. The data obtained in this study showed a reduction in the number of bacterial colonies that grew at each additional sterilization time, thus indicating that the effectiveness of ultraviolet C light sterilization was directly proportional to the length of time of sterilization.

Keywords — Ultraviolet C, Sterilization, Arduino MKR Wifi 1010, UVGI Lamp, 16×2 LCD, Stepper Motor, A4988 Driver, HC-SR 04 Ultrasonic Sensor, Infrared Proximity Sensor

I. INTRODUCTION

Poor hygiene and hygiene are ideal for the growth of microorganisms that can cause things that can harm humans such as diarrhea, poisoning, or even more serious problems such as the spread of deadly disease outbreaks. Along with the outbreak of the SARS-CoV-2 virus (Covid-19), cleanliness and hygiene is a must because of its massive and fast spread. Transmission of SARS-CoV 2 can occur through direct contact, indirect contact, or close contact with an infected person through secretions such as saliva and respiratory tract secretions or respiratory droplets that come out when an infected person coughs, sneezes, talks or sings [1]. It is very likely that without us knowing it, the virus will spread through objects around us such as money, cellphones, keys, and so on, so there is a need for high vigilance regarding the cleanliness and hygiene of these items.

Ultraviolet (UV) light is light that has a shorter wavelength than visible light, so it cannot be seen by the human eye [2]. Although UV waves are invisible to the human eye, some insects, such as bees, can see them. Ultraviolet light has wavelengths ranging from 4nm to 400nm. Based on the ISO-21348 standard, ultraviolet rays are divided into several parts, including ultraviolet A (UVA), ultraviolet B (UVB) and ultraviolet C (UVC) rays.

UVC rays are known to have radiation power that is lethal to microorganisms. UVC rays have the shortest wavelengths and the most energy than UVA and UVB, so UVC rays are usually referred to as the germicidal range because they are very effective at killing bacteria and viruses [3]. The shorter the wavelength in UV light, the greater the effect it has on killing microbes. The sterilization method using UVC light in the food world has been used extensively in the preventive process or preservation of fresh fruit and processed products [4]. The advantage of using UVC light as a sterilization method is that it will not affect humidity, temperature, taste, color, and shape when compared to common sterilization methods such as heating methods [5]. However, one of the disadvantages of ultraviolet light is its low penetration power, therefore, ultraviolet light is only effective for killing microorganisms on surfaces that are directly exposed to ultraviolet light. Maximum absorption of ultraviolet light in cells occurs in nucleic acids, so it is estimated that the main mechanism of damage to cells by ultraviolet light on ribosomes results in mutations or cell death [6].

In this case the researchers implemented an effective and efficient tool that can be used to help people clean and sterilize the items they use daily by applying the method of irradiating UVC radiation with the operation of a touchless sterilizer. Items to be sterilized are placed in the space provided. Within a predetermined time interval, ultraviolet radiation will be emitted to the item. The sterilization system is expected to be able to sterilize items that are used daily more effectively and efficiently to reduce the impact of infectious diseases on unhygienic items.

II. RESEARCH METHOD

In this study, Arduino MKR WiFi 1010 was used as a microcontroller connected to an infrared proximity sensor and an HC-SR04 ultrasonic sensor as an input device, then a 16×2 LCD, a stepper motor, and a UVGI lamp as an output device. The infrared proximity sensor functions as the opening and closing of the tray removed by the stepper motor, as well as a switch to start turning on/off the UVGI lamp. The HC-SR04 ultrasonic sensor functions as a timer setting. The 16×2 LCD functions as a message viewer on the device.

Testing of sterilizers using Arduino-based UVC light was carried out to obtain data on the effectiveness of the device in killing microorganisms. The method used to test the effectiveness of the tool is by microbiological culture. This microbiological culture was carried out using the pour/spread method. The petri dish will be left at room temperature for 1×24 hours, then the bacterial colonies that grow in the petri dish will be counted. The number of bacterial colonies to be counted is from the surface of the goods before (0 minutes) and after being put into the sterilizer (5-60 minutes). The number of bacterial colonies that meet the requirements for sterilization is 0 colonies/cm3. There are 3 types of objects tested, namely cellphones, plates, and glasses. The block diagram design of the tools in this study can be seen in Fig. 1.

III. RESULT AND DISCUSSION

The prototype of the Arduino-based sterilizer design system using ultraviolet C light can be seen in Fig. 2 and 3.

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Fig. 2. The sterilizer uses Arduino-based ultraviolet C light.

Fig. 3. The electronic circuit of the sterilizer uses Arduino-based ultraviolet C light.

Petri dish results of testing the effectiveness of the tool before and after sterilization can be seen in Fig. 4. and Fig. 5.

Fig. 4. Petri dish results of testing the effectiveness of the tool before sterilizing the cellphone.

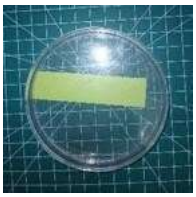

Fig. 5. Petri dishes test the effectiveness of the tool before sterilizing the cellphone for 30 minutes.

A. Test Result of The Infrared Proximity Sensor

At this stage the infrared proximity sensor is given an obstacle in front of the sensor (value 1) whether it is read or not, and vice versa. The test was carried out 4 times, the test results can be seen in Table I.

TABLE I
TEST RESULT OF THE INFRARED PROXIMITY SENSOR

No	Condition	Readability
1	0	No
2	1	Yes
3	0	No
4	1	Yes

Table I shows that the infrared proximity sensor functions properly in 4 tests.

B. Test Result of The Ultrasonic Sensor HC-SR04

This stage is carried out to determine the accuracy of the sensor in detecting distance. Testing is carried out by providing an obstacle in front of the sensor at different distances, then comparing the difference between the sensor distance measurement results and the manual measurement results at each of these distances. The test was carried out 8 times, with a range of 5-40 cm. The test results can be seen in Table II.

TABLE II
TEST RESULT OF THE ULTRASONIC SENSOR HC-SR04

No	Manual Measurement(cm)	Ultrasonic Measurement(cm)	Measurement Difference
1	5	5	±0
2	10	10	±0
3	15	16	±1
4	20	19	±1
5	25	25	±0
6	30	31	±1
7	35	34	±1
8	40	41	±1

Table II shows the HC-SR04 ultrasonic sensor functioning properly in 8 tests with an average difference of about 1 cm.

C. Test Result of The Motor Stepper

At this stage the aim is to find out the difference in the movement of the stepper motor control by giving the command to remove / insert the tray to the A4988 driver and then see if the tray is successfully removed / inserted. The test results can be seen in Table III.

TABLE III
TEST RESULT OF THE MOTOR STEPPER

A.	No	*B.* Movement Resolution	*C.* Results
D.	1	*E.* Remove tray	Succeed
F.	2	*G.* Insert tray	Succeed
H.	3	*I.* Remove tray	Succeed
J.	4	*K.* Insert tray	Succeed

D. Test Result of The UVGI Lamp

This step is carried out to find out whether the UVGI lamp can turn on when the relay is given logic 0/1. The test results can be seen in Table IV.

TABLE IV
TEST RESULT OF THE UVGI LAMP

No	E.	Logic	F.	Result
1	G.	0	H.	Off
2	I.	1	J.	On

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Table IV shows that UVGI lamps function properly in 2 tests.

E. Test Result of The LCD 16×2

At this stage the aim is to check the message display of each sterilizer menu on the screen. The test results can be seen in Table V.

TABLE V
TEST RESULT OF THE LCD 16×2

No	Message	Show on Screen
1	Opener	Yes
2	Welcome	Yes
3	Please put stuff	Yes
4	Choose start/set time	Yes
5	Select timer time	Yes
6	Timer set	Yes
7	Sterilize	Yes
8	Thank You	Yes
9	Wrong choice	Yes
10	Tool reset	Yes

Table V shows that the 16×2 LCD functions properly by displaying all predefined messages in 10 tests.

F. Test Result of The Efectivity of The Sterilizer

At this stage see the effectiveness of the tool in killing microorganisms. The method used to test the effectiveness of the tool is by microbiological culture. This microbiological culture was carried out using the pour/spread method. The petri dish will be left at room temperature for 1×24 hours, then the bacterial colonies that grow in the petri dish will be counted. The number of bacterial colonies to be counted is from the surface of the goods before (0 minutes) and after being put into the sterilizer (5-60 minutes). The number of bacterial colonies that meet the requirements for sterilization is 0 colonies/cm3. There are 3 types of objects tested, namely cellphones, plates, and glasses as can be seen in Fig 6-8

Fig. 6. The cell phone is used as a medium for testing the effectiveness of the sterilizer.

Fig. 7. A plate used as a medium for testing the effectiveness of a sterilizer.

Fig. 8. The glass used as a medium for testing the effectiveness of the sterilizer.

TABLE VI
TEST RESULT OF EFECTIVITY OF THE STERILIZER ON SMARTPHONE

No	Long Time of Sterilization	Number of Colonies	Qualify
1	0 minute	47	No
2	5 minute	28	No
3	10 minute	17	No
4	15 minute	11	No
5	20 minute	9	No
6	30 minute	0	Yes
7	60 minute	0	Yes

Table VI shows the results of testing the sterilizer on cellphones, there were 47 bacterial colonies that grew before the cellphone was sterilized, the number of bacterial colonies decreased with the length of time exposed to ultraviolet light, and reached 0 bacterial colonies when the cellphone was sterilized for 30 minutes.

TABLE VII
TEST RESULT OF THE EFECTIVITY OF THE STERILIZER ON PLATE

No	Long Time of Sterilization	Number of Colonies	Qualify
1	0 minute	37	No
2	5 minute	20	No
3	10 minute	17	No
4	15 minute	10	No
5	20 minute	3	No
6	30 minute	0	Yes
7	60 minute	0	Yes

Table VII shows the results of testing the sterilizer on plates, there were 37 bacterial colonies that grew before the dishes were sterilized, the number of bacterial colonies decreased with the length of time exposure to ultraviolet light, and reached 0 bacterial colonies when the dishes were sterilized for 30 minutes.

TABLE VIII
TEST RESULT OF THE EFECTIVITY OF THE STERILIZER ON CUP

No	Long Time of Sterilization	Number of Colonies	Qualify
1	0 minute	41	No
2	5 minute	27	No
3	10 minute	16	No
4	15 minute	10	No
5	20 minute	5	No

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6	30 minute	0	Yes
7	60 minute	0	Yes

Table VIII shows the results of testing the sterilizer on glass, 41 bacterial colonies grew before the glass was sterilized, the number of bacterial colonies decreased with the length of time exposure to ultraviolet light and reached 0 bacterial colonies when the glass was sterilized for 30 minutes.

IV. CONCLUSION

After going through the planning, design, and trial processes, it was concluded that the research on the Design of Sterilization Equipment using Arduino-based Ultraviolet C Rays is the manufacture of hardware, namely a sterilizer that has been embedded in one box where there is an Arduino MKR WiFi 1010, an infrared proximity sensor module , HC-SR04 ultrasonic sensor module, UVGI lamp with relay, stepper motor with A4988 driver, and 16×2 LCD with touchless I2C module. Based on the results of testing the effectiveness of the sterilizer, it can also be concluded that UVC light can reliably kill microorganisms and its effectiveness increases with the longer irradiation time on the object being sterilized and indicates that the effectiveness of ultraviolet C light sterilization is directly proportional to the length of time of sterilization.

REFERENCE

[1] World Health Organization, “SARS-CoV-2 transmission: implications for infection prevention vigilance," *Scientific statement*, pp. 1–10, 2020, [Online]. Available: who.int. (in Bahasa)

[2] G. Butcher, *Tour of The Electromagnetic Spectrum*, Third Edit. Washington, DC.: National Aeronautics and Space Administration, 2016.

[3] C. A. Bolton J R and Cotton, *The Ultraviolet Disinfection Handbook*. 2008.

[4] A. Müller, M. R. Stahl, V. Graef, C. M. A. P. Franz, and M. Huch, “UV-C treatment of juices to inactivate microorganisms using Dean vortex technology,” *J. FoodEng.*, 2011,doi:10.1016/j.jfoodeng.2011.05.026.

[5] I. D. Arinda and Yunianta, “Effect of Power and Duration of Ultraviolet-C Irradiation on Total Microbes of Salak Pondoh Fruit Juice,” *J. Pangan dan Agroindustri*, vol. 3, no. 4, pp. 1337–1344, 2015.

[6] F. Z. Ramdhani, D. Riyanto, and D. Desriyanti, “Electronic Sterilization of Tableware Using Ultraviolet Light Radiation,” *JEEE-U (Journal Electr. Electron. Eng. UMSIDA*, vol. 4, no. 1, pp. 70– 79, 2020, doi: 10.21070/jeeeu.v4i1.316.