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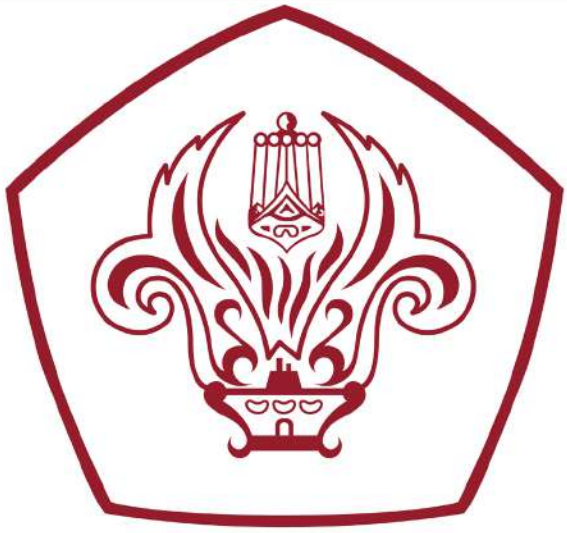

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Ultraviolet C light controller system based on android smartphone FREE

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Ultraviolet C Light Controller System Based on Android Smartphone

Carel Andersent[1 a)], Endah Setyaningsih[1 b)], Yohanes Calvinus[1]

Author Affiliations

[1]*Electrical Engineering Departement, Universitas Tarumanagara, Jl. Letjen S. Parman No.1, Jakarta 11440, Indonesia*

Author Emails

[a)] carel.525170002@stu.untar.ac.id

[b)]Corresponding Author: endahs@ft.untar.ac.id

Abstract. A virus is a microorganism that causes infectious diseases. One of the pandemics in Indonesia in 2021 is caused by a virus named SARS-CoV-2. Both the physical and mental health until the national economy are disturbed by the COVID-19 pandemic. The use of ultraviolet light is intended for killing viruses around us. There are several kinds of ultraviolet light, such as Ultraviolet A (UVA), Ultraviolet B (UVB), and Ultraviolet C (UVC). The wavelength produced by UVC light is 253.7 nm. The wavelength is effective in killing viruses and bacteria. However, UVC light is not safe for humans, especially human skins. A controller system for UVC light is made so it can be safe to be used by humans. The controller system is connected to the internet to control UVC light anywhere and anytime where internet connection is available. This controller system consists of NodeMCU ESP8266 Amica as the processor module and a four-channel Relay Module put together inside a box made from acrylic with dimensions of 9.5 cm × 9 cm × 5 cm. The acrylic box is placed in the room within the Wi-Fi range. The controller system could be accessed by an Android smartphone that has the controller application installed in it. The application in the Android smartphone is designed by MIT App Inventor, which is also connected to Google Firebase. A controller system can control up to four UVC lights for sterilization purposes in some rooms. Controlling UVC lights can be done because of the connection between the application on Android smartphone with real-time database on Google Firebase and the processor module.

Keywords: Virus, ultraviolet C, controller, real-time database, Android, NodeMCU.

INTRODUCTION

Illness and death are problems that always happen in society all around the world. A virus or bacteria can cause the death factor of someone. For example, a disease caused by a virus can infect lots of people in some countries and cause the infected people to death. Some viruses that infect many people because they can spread as droplets or aerosol are influenza, measles, and smallpox [1]. The one that is happening right now is the coronavirus (SARS-CoV-2).

A virus is a microorganism which means it is invisible to the naked eye [2]. This hidden object becomes the most significant problem to prevent viruses get into the human body because we can not prevent something that we can not see. We can not identify whether air or things surrounding are free from viruses or not. We can see microorganisms by using a microscope, but it is almost impossible to bring around a microscope every time, and everywhere we go for daily usage.

As technology develops, there is a way to prevent those viruses even though they are invisible to the naked eye. The method is using ultraviolet light that can affect the cell function of microorganisms. There are kinds of ultraviolet light such as Ultraviolet A (UVA), Ultraviolet B (UVB), and Ultraviolet C (UVC). To overcome the spread of virus issues, using UVC could be the solution. They were choosing UVC as the answer is because UVC

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can affect the cell function of microorganisms and lead to death. The most effective radiation to kill microorganisms is 253.7 nm [3].

This UVC light is not entirely safe for use by human because can cause blindness and hurt human skin. Therefore, the internet is used as data transmission media between the Android smartphone and system module so that the UVC can operate without harming the user's health to make it safer for humans. Internet is used as data transmission media between the user's command and the UVC. The user's command or the input data uses the application on an Android smartphone connected to the internet. The real-time database responds to the input and passes the data onto the processing module connected to the Internet via Wi-Fi to control the UVC. Maintaining the UVC using an application on an Android smartphone through the internet is essential to prevent direct radiation from the UVC.

THE DESIGN CONCEPT

The Ultraviolet C (UVC) light control system is based on an application on an Android smartphone to control UVC lights. This system consists of an application on an Android smartphone, a processing module, a four-channel relay module, four UVC lights, and an adaptor module. Diagram block of UVC light controller system based on an android smartphone is shown in **FIGURE 1**.

Application on an android smartphone is used so that users can communicate with hardware [4]. The application is designed by using MIT App Inventor. MIT App Inventor is used to develop the interface of the application. The commands of virtual buttons of the application are created by using the logic blocks feature inside MIT App Inventor as well. Cloud database is also made for this system to work correctly. A cloud database is a database that runs on a cloud computing platform. Cloud computing is one way to access data that we have using the internet [5]. While designing logic blocks, API token and URL of a real-time database on cloud database is input. The API token and URL are needed to link the application on an android smartphone and the real-time database.

The processing module or microcontroller used in this system is Amica NodeMCU ESP8266. Amica NodeMCU ESP8266 is an electronic board integrated with an ESP8266 12-E chip that functions as a Wi-Fi module. Amica NodeMCU ESP8266 uses Lua programming language and can be programmed using the Arduino IDE compiler. This microcontroller has a micro B-type USB port to import programs from Arduino IDE to the microcontroller [6]. This microcontroller has 11 I/O digital pins that support interrupt function, PWM (pulse width modulation) functionality, I2C, and one analog pin as ADC (analog-digital converter). The operation voltage of this microcontroller is 3.3V, and the input voltage is about 4.5-10V. The frequency rate of this microcontroller is 80MHz [7]. Amica NodeMCU ESP8266 is chosen for this system because this microcontroller has General Purpose Input Output (GPIO) just like other microcontrollers in general. This microcontroller is also integrated with a Wi-Fi chip.

The relay module used in the making of this system is a 5V four-channel relay module. The relay module itself is a device that uses an electromagnet to operate a set of switch contacts. The relay module function as a switch to conduct an electronic device [8]. Due to controlling four UVC lights simultaneously, a four-channel relay module is used in this UVC light controller system based on an android smartphone.

Philips TUV G8 T5 as an ultraviolet C light is used in this system. This 8 watt light is a UVC (germicidal) used in a professional air and water disinfection device. Philips TUV G8 T5 has a diameter of 16 mm, a length of 30 cm, and a peak of UVC wave radiation at 253.7 nm [9]. Due to its dimension, which is not so big, this Philips TUV G8 T5 is chosen for this system.

An adaptor module is also needed to make this UVC light controller system based on Android smartphones. A 5V 1A adaptor module is used to power the processing module that uses a 220V AC power source. In general, an adaptor module is an electronic circuit that converts AC to DC and changes voltage value at once [10]. This 5V adaptor module is chosen due to the processing module needs an input voltage of 4.5V-10V.

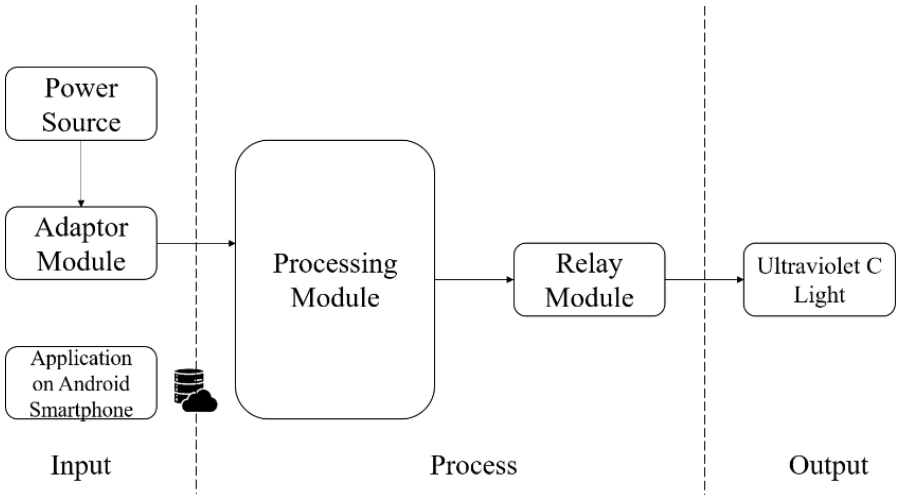

Figure 1. Diagram Block of Ultraviolet C Light Controller System Based On Android Smartphone

THE CONSTRUCTION AND DISCUSSION

Based on the diagram block on **FIGURE 1**, the whole system is built. **FIGURE 2** shows the complete system. **FIGURE 2** shows the top view, consisting of the processing module, relay module, adaptor module, and four UVC lights. The processing module is connected to the adaptor module and relay module. The relay module is connected to four UVC lights using 2 meters long cable for each light. Both the processing module and the relay module are put inside an acrylic box with the dimension of 9.5 cm × 9 cm × 5 cm. A 220V AC power source powers the processing module and UVC lights. **FIGURE 3** shows the interface of the application on an Android Smartphone. It shows four UVC light indicators with an on and off button for each indicator.

All modules such as adaptor, processing, relay, UVC lights, and even the application on smartphone Android are tested to ensure this UVC light controller system's success. The result of the application on Android smartphone testing is shown in **TABLE 1**. Application on Android smartphone is tested to make sure that the design on MIT App Inventor corresponds with the application itself, whether the interface or the function of the virtual buttons.

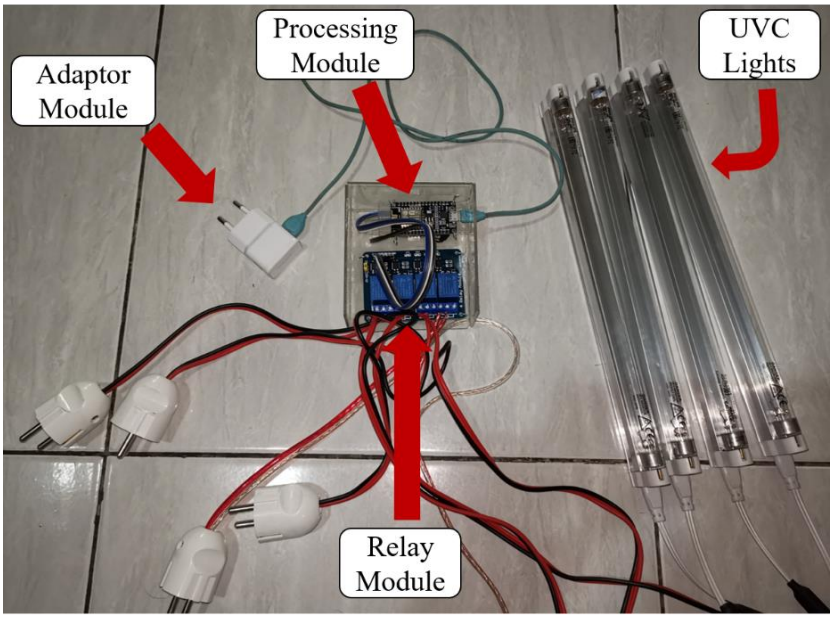

FIGURE 2. The Design Result of Ultraviolet C Light Controller System Based On Android Smartphone

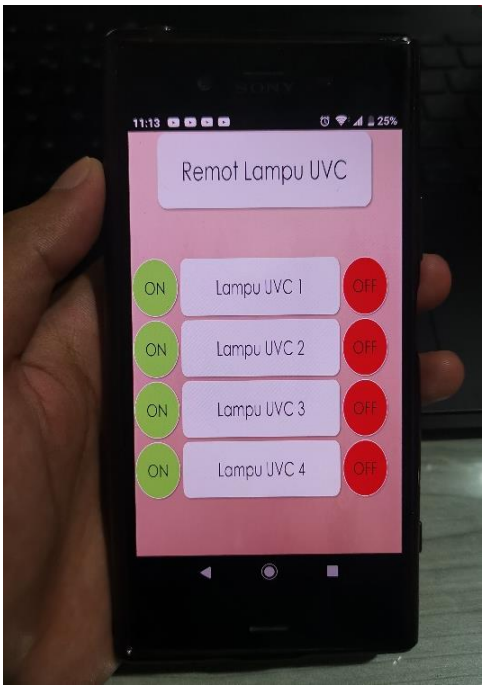

FIGURE 3. The Interface of Application on Android Smartphone

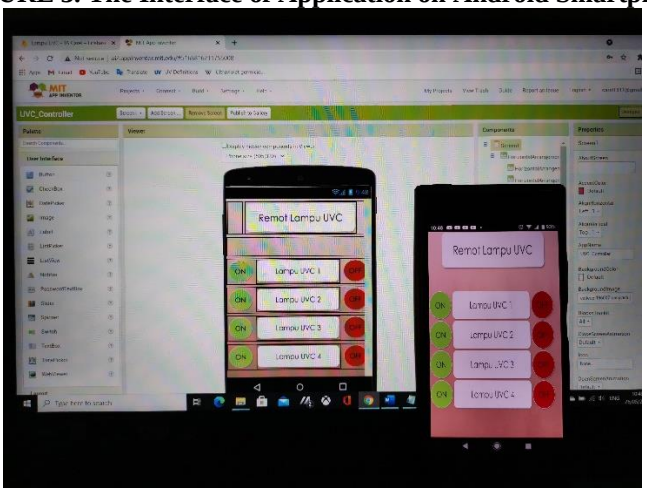

FIGURE 4. Result Design Of Applcation On Android Smartphone

TABLE 1. Results Of Aplication On Android Smartphone

Virtual Button Touched	Result On Realtime Database
ON_1	D1 is 1
ON_2	D2 is 1
ON_3	D3 is 1
ON_4	D4 is 1
OFF_1	D1 is 0
OFF_2	D2 is 0
OFF_3	D3 is 0
OFF_4	D4 is 0

The result of processing module testing is shown in **TABLE 2**. The processing module is connected to the adaptor module and relay module. Then, input a program to connect the processing module to Wi-Fi and to control the relay module. The program input using Arduino IDE. The program input is to control the four-channel relay module. A 4 channel relay module has four indicators for each relay, and the indicators are IN1, IN2, IN3, and IN4. The same API token and URL input in the application is also input in this program. The processing module

and the application connect each other through a real-time database. The adaptor module is meant to power up the processing module. For the input of this testing, the application made before is used.

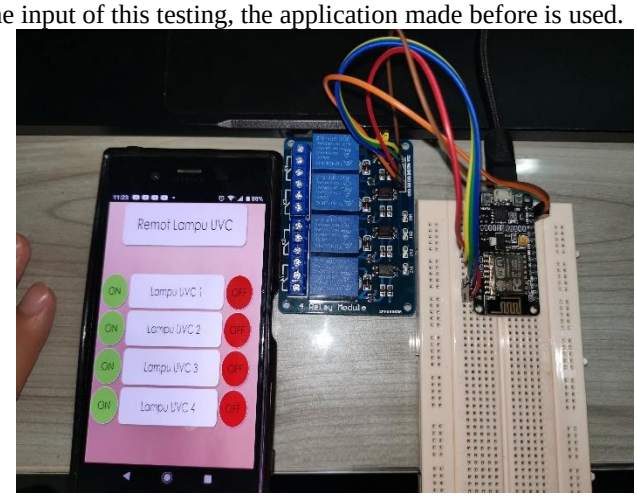

FIGURE 5. Processing Module Testing Circuit

TABLE 2. Result Of Processing Module

Input	Response Of Relay Indicator
ON_1 Button Touched	IN1 ON
ON_2 Button Touched	IN2 ON
ON_3 Button Touched	IN3 ON
ON_4 Button Touched	IN4 ON
OFF_1 Button Touched	IN1 OFF
OFF_2 Button Touched	IN2 OFF
OFF_3 Button Touched	IN3 OFF
OFF_4 Button Touched	IN4 OFF

The result of 4 channel relay module testing is shown in **TABLE 3**. The relay module is connected to a processing module and a cooling fan. The input is still the same, using the application made before. The fan is tested or connected to each relay to ensure the four relays of 4 channel relay modules are working correctly. The input from the application gives commands to the processing module then, from the processing module to the relay module to control the cooling fan.

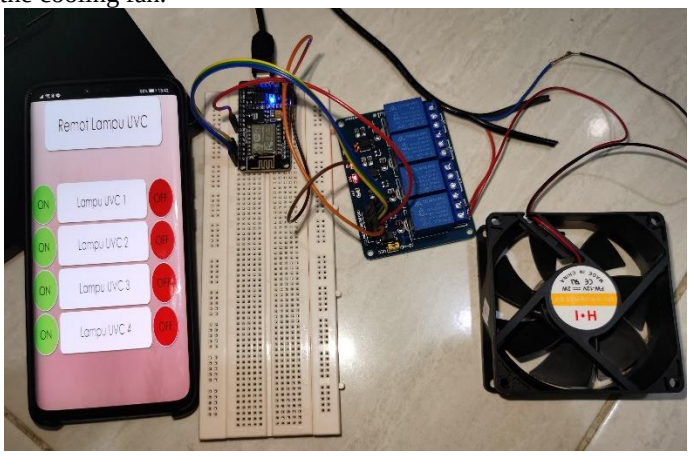

FIGURE 6. 4 Channel Relay Module Testing Circuit

TABLE 3. Result Of 4 Channel Relay Module

Input	Relay Module And Cooling Fan Condition
ON_1 Button Touched	Relay 1 and Cooling Fan ON
ON_2 Button Touched	Relay 2 and Cooling Fan ON
ON_3 Button Touched	Relay 3 and Cooling Fan ON

ON_4 Button Touched	Relay 4 and Cooling Fan ON
OFF_1 Button Touched	Relay 1 and Cooling Fan OFF
OFF_2 Button Touched	Relay 2 and Cooling Fan OFF
OFF_3 Button Touched	Relay 3 and Cooling Fan OFF
OFF_4 Button Touched	Relay 4 and Cooling Fan OFF

The result of ultraviolet C testing is done by plugging it into power source 220V AC. The UVC lights are put inside a room for this test. This test is done to know that the UVC light is working correctly and ensure the effectiveness of this light. This test result is shown in **TABLE 4**. As a result of using UVC light, there is a smell of burning while using it.

TABLE 4. Result Of Ultraviolet C Light

Power Source	Ultraviolet C
HIGH	ON
LOW	OFF

The result of the whole system testing is shown in **TABLE 5**. Testing the UVC light controller system based on an Android smartphone is done by connecting all modules. The adaptor module is used to power up the processing module. Then, the processing module is connected to the relay module. The relay module is also connected to four UVC lights. An Android smartphone application is used to control the whole system. The test for controlling the UVC lights is done twice. The first is when the Android smartphone is connected to the internet via Wi-Fi, and the second is when the Android smartphone is connected to the internet via mobile data.

TABLE 5. Result Of Ultraviolet C (UVC) Light Controller System Based On Android Smartphone Testing

Internet Connection	UVC Light Number-	Input from Application	UVC Light	Delay
Wi-Fi	1	ON	UVC Light number 1 is ON	1.25 Seconds
				0.98 Seconds
				1.63 Seconds
				1.11 Seconds
				2.09 Seconds
		OFF	UVC Light number 1 is OFF	0.92 Seconds
				0.94 Seconds
				1.42 Seconds
				2.00 Seconds
				1.98 Seconds
	2	ON	UVC Light number 2 is ON	2.29 Seconds
				5.05 Seconds
				3.04 Seconds
				3.63 Seconds
				4.00 Seconds
		OFF	UVC Light number 2 is OFF	3.60 Seconds
				3.24 Seconds
				4.50 Seconds
				3.08 Seconds
				4.15 Seconds
	3	ON	UVC Light number 3 is ON	1.51 Seconds
				1.24 Seconds
				1.44 Seconds
				0.85 Seconds
				1.31 Seconds
		OFF	UVC Light number 3 is OFF	2.62 Seconds
				1.24 Seconds
				0.98 Seconds
				1.18 Seconds

				2.75 Seconds
		ON	UVC Light number 4 is ON	1.31 Seconds
				1.14 Seconds
				0.92 Seconds
				1.05 Seconds
	4			1.11 Seconds
		OFF	UVC Light number 4 is OFF	1.70 Seconds
				0.75 Seconds
				0.78 Seconds
				2.16 Seconds
				1.11 Seconds
Mobile Data	1	ON	UVC Light number 1 is ON	1.57 Seconds
				0.85 Seconds
				1.44 Seconds
				0.59 Seconds
				1.31 Seconds
		OFF	UVC Light number 1 is OFF	1.76 Seconds
				0.72 Seconds
				1.57 Seconds
				1.24 Seconds
				1.05 Seconds
	2	ON	UVC Light number 1 is ON	1.83 Seconds
				0.79 Seconds
				1.10 Seconds
				0.85 Seconds
				0.98 Seconds
		OFF	UVC Light number 1 is OFF	0.78 Seconds
				0.78 Seconds
				1.18 Seconds
				0.92 Seconds
				1.20 Seconds
	3	ON	UVC Light number 1 is ON	0.85 Seconds
				1.04 Seconds
				1.10 Seconds
				1.50 Seconds
				3.37 Seconds
		OFF	UVC Light number 1 is OFF	1.52 Seconds
				1.43 Seconds
				1.04 Seconds
				1.57 Seconds
				0.78 Seconds
	4	ON	UVC Light number 1 is ON	2.22 Seconds
				0.90 Seconds
				1.11 Seconds
				1.18 Seconds
				1.11 Seconds
		OFF	UVC Light number 1 is OFF	1.44 Seconds
				1.05 Seconds
				2.29 Seconds
				1.44 Seconds
				0.72 Seconds

CONCLUSION

Based on the testing results of the UVC light controller system discussed before, it is concluded that the system is working as designed, either using a Wi-Fi connection or a mobile data connection. Second is there is a

delay of not more than 6 seconds every time the system is running. It means that the user has to wait 1-5 seconds when the button on the application is touched until the system responded. Third, the existing delay when testing the whole system using mobile data had never reached 4 seconds which means this delay is always lower than the current delay when testing using Wi-Fi which got 5.05 seconds. Last, both the application and processing module are connected to a real-time database, and the UVC lights response proves this matches the input from the application.

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by Endah Setyaningsih

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Author Affiliations

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Author Emails

[a)] carel.525170002@stu.untar.ac.id

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The relay module used in the making of this system is a 5V four-channel relay module. The relay module itself is a device that uses an electromagnet to operate a set of switch contacts. The relay module function as a switch to conduct an electronic device [8]. Due to controlling four UVC lights simultaneously, a four-channel relay module is used in this UVC light controller system based on an android smartphone.

Philips TUV G8 T5 as an ultraviolet C light is used in this system. This 8 watt light is a UVC (germicidal) used in a professional air and water disinfection device. Philips TUV G8 T5 has a diameter of 16 mm, a length of 30 cm, and a peak of UVC wave radiation at 253.7 nm [9]. Due to its dimension, which is not so big, this Philips TUV G8 T5 is chosen for this system.

An adaptor module is also needed to make this UVC light controller system based on Android smartphones. A 5V 1A adaptor module is used to power the processing module that uses a 220V AC power source. In general, an adaptor module is an electronic circuit that converts AC to DC and changes voltage value at once [10]. This 5V adaptor module is chosen due to the processing module needs an input voltage of 4.5V-10V.

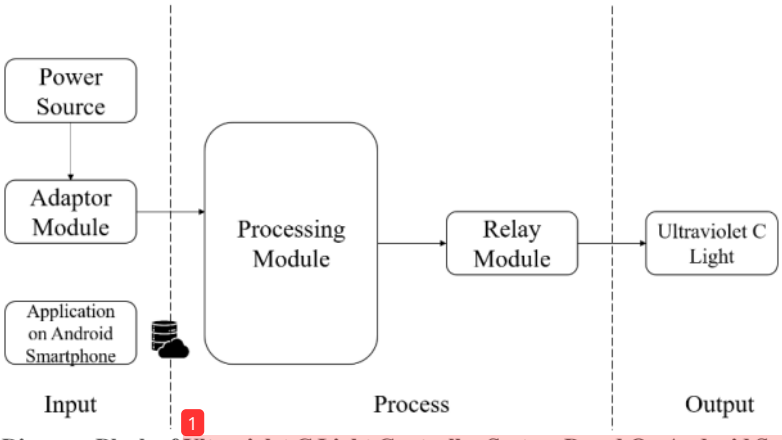

Figure 1. Diagram Block of Ultraviolet C Light Controller System Based On Android Smartphone

THE CONSTRUCTION AND DISCUSSION

Based on the diagram block on **FIGURE 1**, the whole system is built. **FIGURE 2** shows the complete system. **FIGURE 2** shows the top view, consisting of the processing module, relay module, adaptor module, and four UVC lights. The processing module is connected to the adaptor module and relay module. The relay module is connected to four UVC lights using 2 meters long cable for each light. Both the processing module and the relay module are put inside an acrylic box with the dimension of 9.5 cm × 9 cm × 5 cm. A 220V AC power source powers the processing module and UVC lights. **FIGURE 3** shows the interface of the application on an Android Smartphone. It shows four UVC light indicators with an on and off button for each indicator.

All modules such as adaptor, processing, relay, UVC lights, and even the application on smartphone Android are tested to ensure this UVC light controller system's success. The result of the application on Android smartphone testing is shown in **TABLE 1**. Application on Android smartphone is tested to make sure that the design on MIT App Inventor corresponds with the application itself, whether the interface or the function of the virtual buttons.

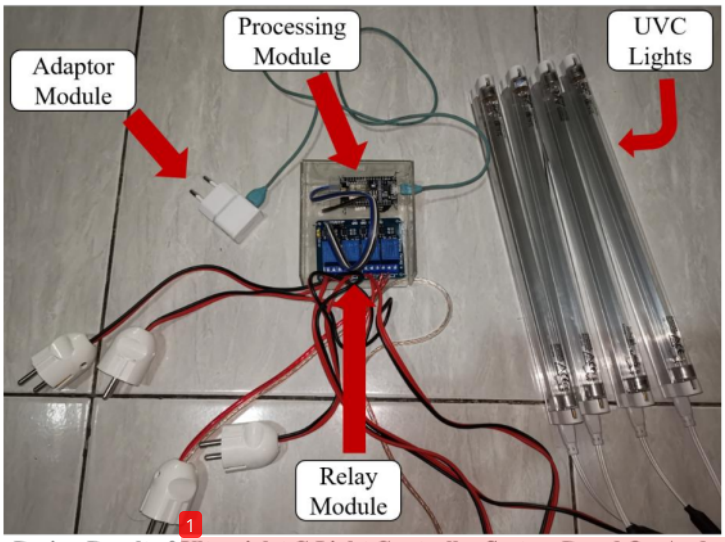

FIGURE 2. The Design Result of Ultraviolet C Light Controller System Based On Android Smartphone

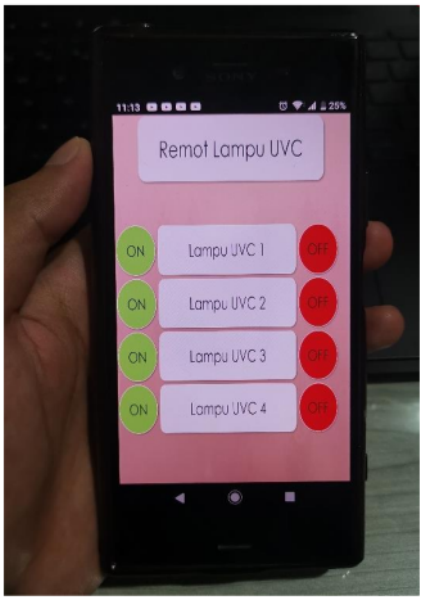

FIGURE 3. The Interface of Application on Android Smartphone

FIGURE 4. Result Design Of Applcation On Android Smartphone

TABLE 1. Results Of Aplication On Android Smartphone

Virtual Button Touched	Result On Realtime Database
ON_1	D1 is 1
ON_2	D2 is 1
ON_3	D3 is 1
ON_4	D4 is 1
OFF_1	D1 is 0
OFF_2	D2 is 0
OFF_3	D3 is 0
OFF_4	D4 is 0

The result of processing module testing is shown in **TABLE 2**. The processing module is connected to the adaptor module and relay module. Then, input a program to connect the processing module to Wi-Fi and to control the relay module. The program input using Arduino IDE. The program input is to control the four-channel relay module. A 4 channel relay module has four indicators for each relay, and the indicators are IN1, IN2, IN3, and IN4. The same API token and URL input in the application is also input in this program. The processing module

and the application connect each other through a real-time database. The adaptor module is meant to power up the processing module. For the input of this testing, the application made before is used.

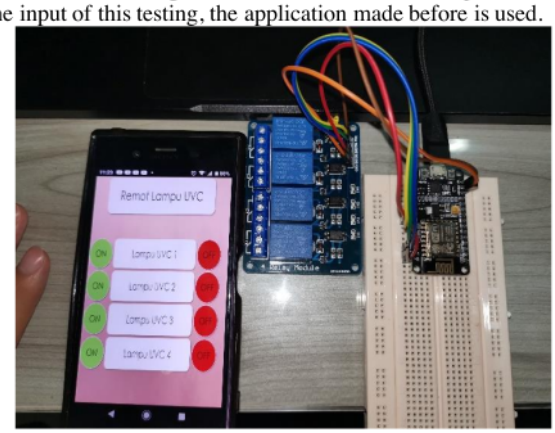

FIGURE 5. Processing Module Testing Circuit

TABLE 2. Result Of Processing Module

Input	Response Of Relay Indicator
ON_1 Button Touched	IN1 ON
ON_2 Button Touched	IN2 ON
ON_3 Button Touched	IN3 ON
ON_4 Button Touched	IN4 ON
OFF_1 Button Touched	IN1 OFF
OFF_2 Button Touched	IN2 OFF
OFF_3 Button Touched	IN3 OFF
OFF_4 Button Touched	IN4 OFF

The result of 4 channel relay module testing is shown in **TABLE 3**. The relay module is connected to a processing module and a cooling fan. The input is still the same, using the application made before. The fan is tested or connected to each relay to ensure the four relays of 4 channel relay modules are working correctly. The input from the application gives commands to the processing module then, from the processing module to the relay module to control the cooling fan.

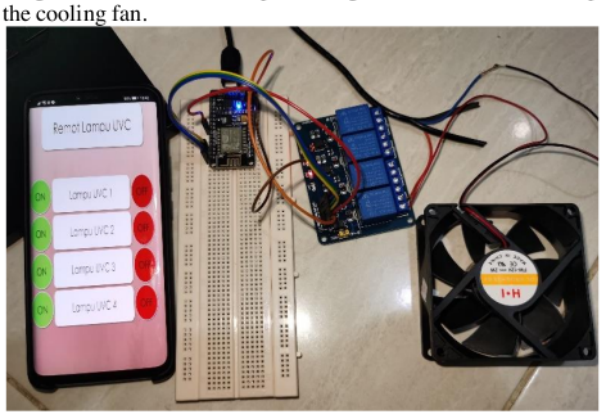

FIGURE 6. 4 Channel Relay Module Testing Circuit

TABLE 3. Result Of 4 Channel Relay Module

Input	Relay Module And Cooling Fan Condition
ON_1 Button Touched	Relay 1 and Cooling Fan ON
ON_2 Button Touched	Relay 2 and Cooling Fan ON
ON_3 Button Touched	Relay 3 and Cooling Fan ON

ON_4 Button Touched	Relay 4 and Cooling Fan ON
OFF_1 Button Touched	Relay 1 and Cooling Fan OFF
OFF_2 Button Touched	Relay 2 and Cooling Fan OFF
OFF_3 Button Touched	Relay 3 and Cooling Fan OFF
OFF_4 Button Touched	Relay 4 and Cooling Fan OFF

The result of ultraviolet C testing is done by plugging it into power source 220V AC. The UVC lights are put inside a room for this test. This test is done to know that the UVC light is working correctly and ensure the effectiveness of this light. This test result is shown in **TABLE 4**. As a result of using UVC light, there is a smell of burning while using it.

TABLE 4. Result Of Ultraviolet C Light

Power Source	Ultraviolet C
HIGH	ON
LOW	OFF

The result of the whole system testing is shown in **TABLE 5**. Testing the UVC light controller system based on an Android smartphone is done by connecting all modu The adaptor module is used to power up the processing module. Then, the processing module is connected to the relay module. The relay module is also connected to four UVC lights. An Android smartphone appli ion is used to control the whole system. The test for controlling the UVC lights is d twice. The first is when the Android smartphone is connected to the internet via Wi-Fi, and the second when the Android smartphone is connected to the internet via mobile data.

TABLE 5. Result Of Ultraviolet C (UVC) Light Controller System Based On Android Smartphone Testing

Internet Connection	UVC Light Number-	Input from Application	UVC Light	Delay
Wi-Fi	1	ON	UVC Light number 1 is ON	1.25 Seconds
				0.98 Seconds
				1.63 Seconds
				1.11 Seconds
				2.09 Seconds
		OFF	UVC Light number 1 is OFF	0.92 Seconds
				0.94 Seconds
				1.42 Seconds
				2.00 Seconds
				1.98 Seconds
	2	ON	UVC Light number 2 is ON	2.29 Seconds
				5.05 Seconds
				3.04 Seconds
				3.63 Seconds
				4.00 Seconds
		OFF	UVC Light number 2 is OFF	3.60 Seconds
				3.24 Seconds
				4.50 Seconds
				3.08 Seconds
				4.15 Seconds
	3	ON	UVC Light number 3 is ON	1.51 Seconds
				1.24 Seconds
				1.44 Seconds
				0.85 Seconds
				1.31 Seconds
		OFF	UVC Light number 3 is OFF	2.62 Seconds
				1.24 Seconds
				0.98 Seconds
				1.18 Seconds

				2.75 Seconds
				1.31 Seconds
				1.14 Seconds
		ON	UVC Light number 4 is ON	0.92 Seconds
				1.05 Seconds
	4			1.11 Seconds
				1.70 Seconds
				0.75 Seconds
		OFF	UVC Light number 4 is OFF	0.78 Seconds
				2.16 Seconds
				1.11 Seconds
				1.57 Seconds
				0.85 Seconds
		ON	UVC Light number 1 is ON	1.44 Seconds
				0.59 Seconds
	1			1.31 Seconds
				1.76 Seconds
				0.72 Seconds
		OFF	UVC Light number 1 is OFF	1.57 Seconds
				1.24 Seconds
				1.05 Seconds
				1.83 Seconds
				0.79 Seconds
		ON	UVC Light number 1 is ON	1.10 Seconds
				0.85 Seconds
	2			0.98 Seconds
				0.78 Seconds
				0.78 Seconds
		OFF	UVC Light number 1 is OFF	1.18 Seconds
				0.92 Seconds
Mobile Data				1.20 Seconds
				0.85 Seconds
				1.04 Seconds
		ON	UVC Light number 1 is ON	1.10 Seconds
				1.50 Seconds
	3			3.37 Seconds
				1.52 Seconds
				1.43 Seconds
		OFF	UVC Light number 1 is OFF	1.04 Seconds
				1.57 Seconds
				0.78 Seconds
				2.22 Seconds
				0.90 Seconds
		ON	UVC Light number 1 is ON	1.11 Seconds
				1.18 Seconds
	4			1.11 Seconds
				1.44 Seconds
				1.05 Seconds
		OFF	UVC Light number 1 is OFF	2.29 Seconds
				1.44 Seconds
				0.72 Seconds

CONCLUSION

Based on the testing results of the UVC light controller system discussed before, it is concluded that the system is working as designed, either using a Wi-Fi connection or a mobile data connection. Second is there is a

delay of not more than 6 seconds every time the system is running. It means that the user has to wait 1-5 seconds when the button on the application is touched until the system responded. Third, the existing delay when testing the whole system using mobile data had never reached 4 seconds which means this delay is always lower than the current delay when testing using Wi-Fi which got 5.05 seconds. Last, both the application and processing module are connected to a real-time database, and the UVC lights response proves this matches the input from the application.

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