Academy of Romanian Scientists
University of Oradea, Faculty of Electrical Engineering and Information Technology

Volume 15, Number 2, October 2022

Journal of Electrical and Electronics Engineering

University of Oradea Publisher

ISSN 1844 - 6035

This volume includes papers in the following main topics: Electromagnetic field analysis and applications, Microwaves, Electrotechnologies, Energy conversion, Electrical drives and electromechanical systems, Electric and electronic measurement systems, Electronics, Telecommunications, Signal Processing, Multimedia Systems, Cellular Neural Networks, Robotics, Power Systems and Power Electronics, Linear and Non-linear Circuits, Management, Image processing, Medical applications.

SUMMARY

Development of A Low End Arduino Based Automatic Disinfectant Sprayer for New Normal Classroom

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Abstract* – Covid-19 is an infectious disease that attacks the respiratory system caused by the coronavirus found in 2019. It has a deadly infection and rapid spread worldwide without exception in Indonesia. Then since the year, World Health Organization (WHO) has declared it a world pandemic. One way to prevent the spread of Covid-19, especially in the closed public area, is by spraying disinfectant to kill the virus. In this project, a low-end disinfectant sprayer has been built based on an Arduino system. The sprayer has been applied to a 10.3mx7.8m classroom with 30 units of the misting device. Performance test of the system shows that the sprayer can work accurately at the timetable to spray the classroom by consuming 58.31W in operation and 19.80W in standby mode. The total hardware implementation cost is IDR 904,225 or less than USD 65, making affordability for implementing the system.

***Keywords:* Covid-19, sprayer, Arduino; classroom.**

I. INTRODUCTION

The Covid-19 pandemic has affected many countries as well as Indonesia. In the pandemic situation, people tried to create tools that could further cut the disease from spreading while thriving for a living. Healthy lifestyles and technological innovation, especially in public facilities, will prevent the spread of the disease. In the open area, one way to prevent the spread of the virus is by spray disinfectant, either continuously or on schedule. The problem that may arise will be the efficiency of spraying due to human resources, the large area to cover, and the population who take the service[1]. Optimization disinfectant spraying can reach by automatization of the spray system. In the "New Normal" which means normal activities in a pandemic situation, people need to work outside and do other activities.

Arduino, an open-source single-board microcontroller, is used in various fields. Hardware in Arduino consists of several types depending on the usage of the microprocessor, but in general, it is provided with an Atmel AVR processor. The differences between Arduinos are in the additional functions in each board and the type of microcontroller used [2]. Arduino Uno is one of the products labeled Arduino, an electronic board containing the ATMega328 microcontroller [3]. Arduino boards have been using for helping human in facing the Covid-19 diseases in previous research i.e. preventing the virus spreading [4]–[8] and monitoring the patients that are exposed to the virus [9]–[13]. On the other hand, the usage of Arduino as sprayers are mostly in hand sanitizer [6], [7], pesticides sprayer [14], and disinfectant [1], and water control [15].

In terms of study activities, especially in the classroom, a system that can effectively spray disinfectant to the classroom automatically has never been reported. The objectives of this project are to develop a sprayer system based on an Arduino board, to apply the sprayer for preventing the spreading of the Covid-19 virus in a classroom, and to minimize the budget of implementing the sprayer system.

II. METHODS

A. *System Design*

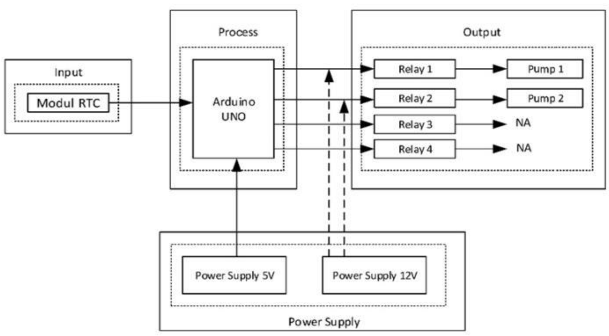

Fig.1: Block diagram of the system

Block diagram of the automatic disinfectant sprayer consist of power supply block, input block, process block, and output block show in Fig.1.

The power supply block is a block that has two adaptors which are 12V 5A adaptor that functions as the main power supply and 5V adaptor as Arduino UNO power supply. The input block consists of the RTC module as a time reader. The process block is the system's brain that uses Arduino UNO as its component. The output block is the controlled part that consists of 4 relay channels that function as a water pump switch.

B. Hardware

The main hardware of the disinfectant sprayer can be explained as follows.

1) Arduino UNO R3

Arduino is the brand name of an open-source single-board microcontroller designed to facilitate electronics in various fields. Hardware (hardware) has an Atmel AVR processor, and software (software) has its own programming language. The AVR family of microcontrollers is equipped with an ADC so that it can be used for I/O from analog circuits [3], [8], [14].

The open-source IDE used has many libraries to facilitate Arduino-based board programming. These advantages make microcontroller applications based on the Arduino platform very flexible in programming so that it quickly becomes popular and widely used in various fields.

Arduino comes with various types of board, and Arduino UNO R3, which is used in this project, is the first product that has some specifications shown in Table 1 [3], [8], [14]. The Arduino Uno R3 board is figured in Fig. 2.

TABLE 1. Arduino Uno R3 Specification.

Specification	Unit
Working voltage	5V
Input voltage	7-12V
Digital I/O	14 pin
Analog input	6 pin
DC current per I/O pin	40 mA
Flash memory	32KB
SRAM	2 KB
EEPROM	1 KB
Clock	16MHz

Fig.2: Arduino UNO R3 Board

2) Relay Module

A relay is a type of switch operated electrically using electromagnetic principles. It consists of an electromagnet coil and a set of switch contacts as the mechanical part. Relay is used to move the switch contacts with a small electric current to conduct higher voltage electricity. A relay that uses a 5V and 50mA electromagnet can move the armature relay, which functions as a switch to deliver 12V voltage with a current of 5A.

In this project, a relay module is used to switch the pump ON/OFF. The relay module is a 5V DC relay with four channels that can switch 10 A loads, as shown in Fig. 3.

Fig.3: Relay Module

3) Water pump

A water pump is used to move a liquid or fluid from one place to another through a channel pipe/hose using electrical energy, which is converted into motion energy using an electric motor. The motor rotates the water turbine to push the fluid to move continuously. The water pump operates on the principle of making a difference on the outlet side and the suction side; the pressure difference results from a mechanism in the propeller wheel, which makes the pressure on the suction side higher than the outlet side. This pressure sucks the liquid to move from one reservoir to another.

Fig.4: Water Pump

The pump used in this project is a 12V 4A DC pump with a maximum pressure of 8.3 bar. The water pump system is given in Fig. 4.

4) Power Supply

A power supply is an electrical device that can provide electrical energy for electrical or other electronic devices. Basically, a power supply requires a source of electrical energy, which then converts it into electrical energy needed by other electronic devices. Therefore, the power supply is sometimes referred to as an electric power converter.

The power supply used in this project is a Switch-Mode Power Supply (SMPS) which provides 5V DC for the controller circuit, including Arduino, relay, and RTC and 12 VDC for supplying the water pump. SMPS is a power supply that directly rectifies and filters the AC input voltage to get a DC voltage. The DC voltage is then switched ON and OFF at high frequency with a high-frequency circuit to produce AC current passing through the High-Frequency Transformer.

5) Real-Time Clock

Real-Time Clock (RTC) is an electronic clock in a chip that can accurately calculate time from seconds to years. It can store the time data in real-time so that after the countdown process is done, the output data is directly stored or sent to other devices through the system interface.

RTC chips are often found on PC motherboards, usually located close to the BIOS chip. The RTC is used to store the current clock information of a computer. It is equipped with a battery that supplies power to the chip, staying up-to-date even when the computer is turned off. Time counted in an RTC is accurate because it uses a crystal oscillator as its clock. Typically the voltage operation of an RTC is in between 2.3V and 5.5V, and the working temperature is laid from -45ºC to +80ºC. Fig.5 shows the physic of an RTC.

Fig.5: RTC

The functions of each pin of the RTC are:

- Vcc : serves as the main source of electrical energy. The working voltage of this component is 5 volts.
- GND : serves as the ground line on the RTC.
- SCL : functions as a clock channel for data communication between the microcontroller and RTC.
- SDA : functions as a data channel for data communication between the microcontroller and RTC
- X1, X2: function for clock channels sourced from external crustals.
- Vbat : serves as a channel of electrical energy from an external battery.

Overall, the tools and spare parts used in this project and those prices are given in Table 2.

TABLE 2. Tools and Spare-parts.

Name	Amount	Unit
Arduino UNOR3 Atmega328	1	piece
Relay module	1	piece
Sinleader 12V DC Pump	2	piece
5/16 water pass hose	23	meter
RTC DS3231	1	piece
30 cm Female to Female Jumper	25	piece
30 cm Male to Female Jumper	25	piece
30 cm Male to Male Jumper	25	piece
Multi-meter	1	piece
Disinfectant tank	1	piece
Misting orange	10	piece
Cable ties	3	bundle
Disinfectant	30	liter
Adaptor 12V 5A	2	piece
Adaptor 5V 1A	1	piece

C. Flowchart Diagram

The system flow diagram can be shown in Fig. 6. It can be seen in the figure that this designed control system does not have a STOP block, so this system will continue to work as long as it is given a power source (loop forever).

The system is started by the initialization of all parameters. In this condition, there are timer settings for a week classroom usage. The system will read serial input that includes the day, time, and course name. In the case of a given serial input, the system will continue to set the timer. Then the system will loop to compare the RTC time and setting time. If equal, the pump will be turned ON for about 10 seconds to spray the disinfectant. Then the system status will be sent via serial communication, and it will loop again.

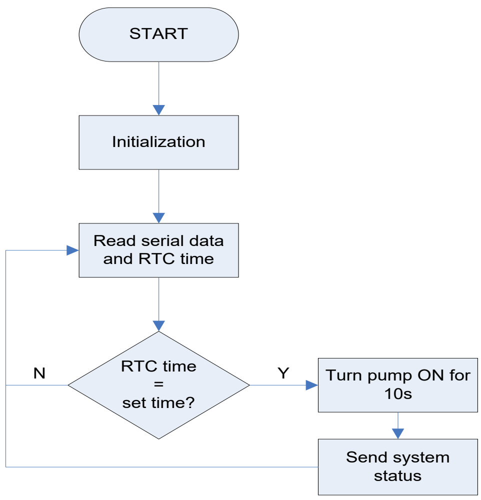

Fig.6: Flowchart Diagram

III. RESULT AND DISCUSSION

A. *System Implementation*

The sprayer system design can be divided into two parts; the first is a hardware design, and the second is software design. Hardware design is electronics design as well as spare parts assembly, and the electronics design of the system adjusts to the input requirement of each electronic component. Fig.7 shows the system's overall configuration, which connected the Arduino microcontroller to RTC, while Fig.8 shows the system installation diagram within the classroom with the dimension of 10.3m x 7.8m. The system design is showed in Fig.7 as follows.

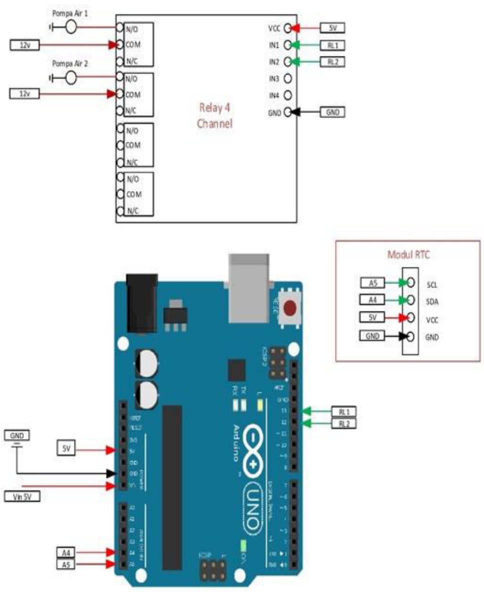

Fig.7: Electronic Circuit Part

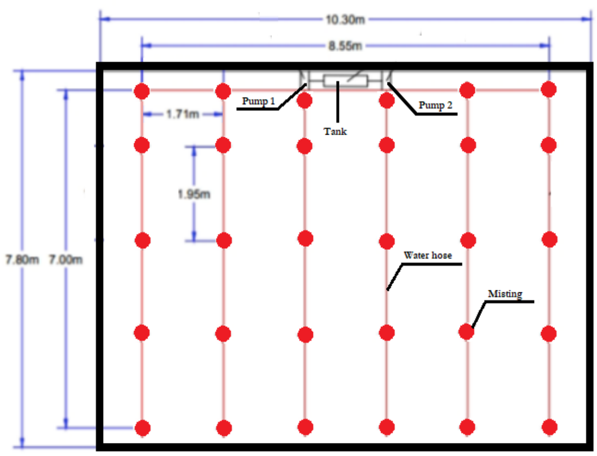

Fig.8: Misting Device Placement

The software design of sprayer system is done in Arduino IDE system to create the system firmware based on the given flowchart in Fig. 6. Then the firmware is embedded to the Arduino Uno as its main routine work. The part of the programming firmware is given in Fig. 9.

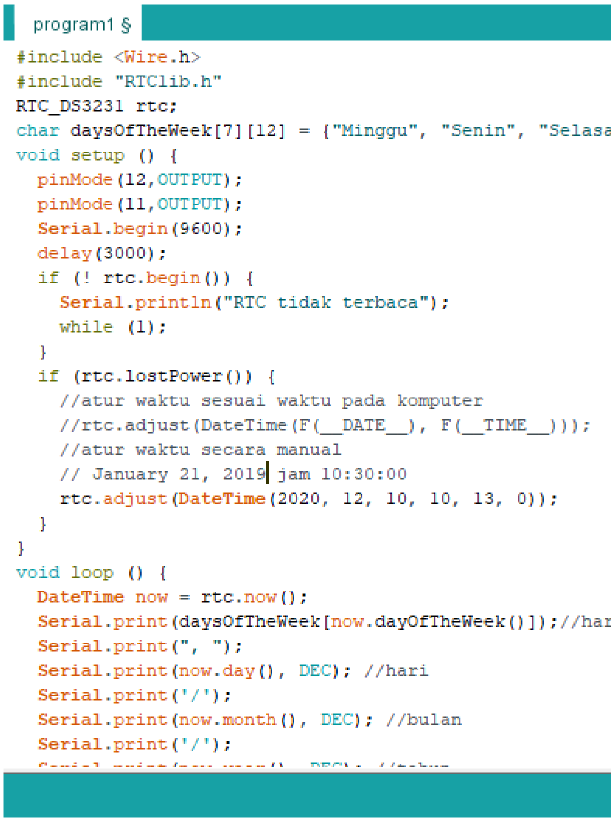

Fig.9: Firmware

The sprayer system for the new normal classroom is designed using an Arduino Uno R3 board as its main part. The processes inside the microcontroller are based on the flowchart in Fig.6. The other external parts are a relay module with four relays and a Real-Time Clock (RTC) module. The RTC module is used as the system time, and it is used to anticipate the time bias due to the power grid shutdown. The complete system block diagram is given in Fig.1.

The automatic disinfectant sprayer system will be attached to the classroom ceiling. The automatization uses an ATMega328 microcontroller on the Arduino UNO board and a classroom schedule to arrange the spraying time accordingly. The water control from the tank to the misting system is manages by the relay module.

B. *System Operation*

The system will automatically work according to the class timetable. For example, the first class on Monday is the "Basic Control System" course for the third-semester student that will perform at 07:30–09:10 Eastern Indonesia Time (EIT). The system will spray the classroom automatically 30 minutes before the class starts (07.00 EIT) for about 10 seconds. The user can set the 30 minutes of space-time according to the class timetable. The rules will work for the other class on the day, but not for an unscheduled class. The system works automatically to spray disinfectant but refill the disinfectant tank. The flowchart used to explain the system workflow is shown in Fig.6.

The automatic disinfectant sprayer operates using some protocols. The protocol starts by making sure the system connects to 220V AC grid lines before turning on the system and inputting the class timetable into the system. The system will work as programmed to process the sprayer based on the given timetable. Because the system is designed to make the loop forever, the system can be turned off by unplugging the power supply cord that connects to the 220V AC network.

The automatic disinfectant sprayer operates using some protocols. The first protocol is to make sure the system connects to 220V AC grid lines before turn on the system. Then, input the class timetable into the system. The system will work as programmed to process the sprayer based on the given timetable. Because the system is desgined to do the loop forever, the system can be turn off by unpluging the power supply cord that connects to the 220V AC network.

C. *System Test*

The test that runs aims to acquire data and the error rate of the system. The test conducts on two functions, functional test and performance test. The functionality test is completed by testing the characteristics and functions of each part of the system. This test investigates whether the system works properly or the other way around. In the same way, the performance test identifies whether or not the system works as it intended to.

The functional test conducts on the system and parts such as a microcontroller, relay, RTC, water pump, and power supply. The microcontroller used is Arduino UNO that tested with the input of the programmed codes to ArduinoIDE software. The relay was tested using the microcontroller with a digital input signal that works as a switch. At the test, the input signal is HIGH, and then the relay on N/O is connected and on N/C disconnected. On the other hand, while the input signal is LOW, the relay on N/O is disconnected and on N/C connected. This condition explained that the system works properly.

TABLE 3. Electrical Measurement.

Measurement \ Condition		Standby	Operation
Voltage (V)	RTC	5.06	4.82
	Relay	4.55	3.82
	Arduino	5.10	4.95
	Pump	12.00	11.04
Current (A)	RTC	0.0054	0.0054
	Relay	0.0000	0.1234
	Arduino	0.1173	0.1173
	Pump	1.66	4.76
Power (W)	Controller	1.08	1.19
	Pump	18.72	57.12
	Total	19.80	58.31

The RTC is assessed by input code to Arduino IDE and checks the RTC can read it. The water pump test is achieved by using a 220V power supply—furthermore, the power supply test is accomplished using a 12V 5A adaptor.

The performance test is run online by sending the name of the course and the schedule. Then the system state is monitored through serial communication. The result of the system performance test shows that the system can work at the class timetable. This test is performed to ensure that the system can operate without any problem. Electrical measurement on the process of both operation and standby modes is given in Table 3.

D. *Economic Analysis*

The sprayer system is designed so that the cost can be minimized. Then it can be implemented in many classrooms on a minimum budget.

TABLE 4. Budget expenditure.

Name	Amount	Unit (IDR)
Arduino UNO R3 ATMega328	1 piece	75,000
RTC DS3231	1 piece	22,500
30 cm Male to Male Jumper	25 pieces	11.875
30 cm Male to Female Jumper	25 pieces	11,875
30 cm Female to Female Jumper	25 pieces	11,875
Sinleader 12V DC Pump	2 pieces	264,100
Relay module	1 piece	43,000
Misting orange	30 pieces	120,000
Water pass hose	23 meters	69,000
Cable	15 meters	75.000
Adaptor	2 pieces	200,000
Total budget		904,225

The detail of the budget to purchase the hardware is given in Table 4. The total expenditure to build the system is IDR 904,225, which is not reached USD 65. The price is affordable for the system that can accommodate people.

IV. CONCLUSIONS

The design and assembly of automatic disinfectant sprayer have succeeded its purpose in 10.3 m x 7.8 m classroom. The sprayer outlet arranges at 30 places with five misting for each point. According to the class timetable programmed on the Arduino UNO board, the spraying process works perfectly. The implementation of the sprayer system takes a total cost of IDR 904,225, which is less than USD 65 while consuming power about 58.31W in operation and 19.80W in standby mode. The total budget for the system is affordable, thus applicable to many classrooms.

V. ACKNOWLEDGEMENT

We thank our colleagues from University of Papua, Manokwari, who provided insight and expertise that greatly assisted this research.

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