Radio Frequency-based Smart Control for Lighting in Public Service

M Rifai\(^1\), A Z Arfianto\(^2\)*, and A T Muzazanah\(^2\)
\(^1\)Dept. of Air Navigation, Politeknik Penerbangan Surabaya, Surabaya, Indonesia
\(^2\)Dept. of Marine Electrical Engineering, Politeknik Perkapalan Negeri Surabaya, Surabaya, Indonesia

*Corresponding author: fifzuhri@ieee.org

Abstract. In the context of energy efficiency, the control function of electrical equipment is an essential part of saving electricity consumption. That is proven by several previous studies about the control of electrical equipment that has been successful for efficiency. In this study, electrical equipment will be controlled in public service buildings, using radio frequency (RF) and the internet. The realization of this research is to make a radio frequency prototype and an internet-based light control device. For the buildings whose location is difficult to reach by the internet, light control uses radiofrequency. While for buildings that are affordable by internet access, using the internet to control the light. In this study, the microcontroller used is ESP 8266 MCU Node and TCM 3105 FSK IC Modem for connection to the internet. Device performance in running controls measured by the delay. Delay is the time difference between the command input time and the time the device has run the command. The average delay is at an average distance of 1513 ms at a distance of 1 m, 2844 ms at a distance of 10 m, 4674 ms at a distance of 100 m, 4060 ms at a distance of 150 m and 3151 ms at a distance of 300 m. The delay value decreases because, at distances of 100, 150, and 300 m the connections are lost. Under these conditions, the delay value is considered empty (0) so that the average decreases. The farther the distance, the higher the percentage of unconnected, this can be seen at distances of 100, 150, and 300 m.

1. Introduction
The development of technology and science, especially in the field of control engineering, has developed rapidly. This development facilitates communication and control of electronic devices, especially public street lighting. The use of public street lighting is one of the various efforts made for energy efficiency. One of the efficiency efforts is power-saving consisting of AC Voltage Controller circuit, a thyristor driver circuit, light sensor circuit, a timer circuit, voltage sensor circuit, and current sensor circuit \([1–3]\). In other fields regarding public street lighting (PJU), energy efficiency has also been carried out in the use of the type and number of lights used. The effectiveness of public street lighting uses LED lights by adjusting the amount of LED lights that turned on. By using LED lights, it can save power \([4]\).

In the context of energy efficiency, the control function of electrical equipment is an essential part of saving electricity. Several studies on electrical equipment controls proved this. Control electrical equipment in the building using radio frequency \([5]\), other than that, the control systems for household appliances based on HT (handy talkies) and microcontrollers AT89S51 \([6]\). The use of radiofrequency for light control has been carried out on home devices. Research on household electrical equipment control systems using HT radio frequency as a remote-control media aims to obtain a control circuit design using HT radio and to find out its performance. The subject of this research is a system built in a...
remote-control system using a 2-meters radio transceiver to transmit coded data in the form of DTMF (Dual Tone Multiple Frequency) signals. This system uses the AT89S51 microcontroller as the central processor. The receiver part of the control object series captures, amplifies, converts to a 4-bit binary number and will be processed by AT89S51 so that it can control electronic equipment on/off [7,8].

Moreover, the building has also used HT for control. The problem that often arises when controlling the lights using manual way is the complexity in managing the lights. This complexity occurs if the room is far away with many lights. The control is not effective and efficient, because it still requires operator power to monitor the lights in each room. Open-loop still allows problems because the status of the lights is not surely detected. From this problem, it is necessary to have a method of controlling lights with the closed-loop system using radiofrequency [9–11].

This research is to make a prototype of radio frequency-based public street lighting for light control device and a microcontroller. For specific areas that are difficult to reach by operators or officers responsible for light control, use light controls to facilitate work. If in the previous study also used radio frequency (RF) in this study, the microcontroller used was ESP 8266 MCU Node with TCM FSK IC Modem. By using ESP 8266 MCU Node microcontroller, it is expected that in the future this system can work dual modes, namely radio frequency and internet-based.

2. Methods
In this study, the design stage that was carried out for the first time was to make a hardware block diagram, then to choose the components and characteristics that matched the needs. This design phase has two stages, namely, hardware design and software design. The hardware design includes the design of the Arduino Uno microcontroller system, ESP 8266 MCU Node, 2 Lupax HT, TCM 3105 FSK IC Modem, Relay Module, Stepdown 5V DC, HPL LED lights, Digital Keypad, and LCD.

![Lamp Control System Diagram](image)

**Figure 1. Lamp Control System Diagram**

While the design of the software includes making programs in the Arduino IDE 1.8.7 application software, Balsamiq Mockup, and Notepad. The first step of design is to determine a system that will be created and to know the working principle. Next is to describe the processes that will be done in the block diagram. This process is carried out to find out the order in making a tool. The system that will be created in this design is a light control system using ESP 8266 MCU Node and RF circuit using TCM
3105 FSK IC modem. The purpose of this design is to make it easier for operators to control the public street lighting lights whose lights only operate during certain hours. Besides, it can also be controlled remotely so that the operator does not need to come to the location to turn off and turn on the lights.

The diagram illustrates (Figure 1) the flow of the lighting control system using the ESP 8266 RF circuit using TCM 3105 FSK IC modem. From the power supply, it will go out to Steppdown 5V DC or DC regulator for voltage output stabiliser. The first series uses the MCU ESP 8266 node as an Internet of Things (IoT) product. From the MCU esp 8266 node goes out to Arduino Mega then to the relay module to be able to control the lights.

In the first series, Mega Arduino is given input from TCM 3105 and handy talkie (HT) FSK IC modems as receivers or receivers. Then for the RF circuit, the power supply goes out to Arduino Uno then to the digital keypad, LCD, TCM 3105 and handy talkie (HT) FSK IC modem as the sender or transmitter.

![Figure 2. Configuring the Relay Module to Led](image)

![Figure 3. Arduino Uno R3 I / O configuration on the Digital Keypad](image)

![Figure 4. Arduino Uno R3 I / O configuration on the TCK Modem IC TCM 3105](image)

![Figure 5. Design of wiring system diagrams](image)

The relay module is an electronic device that can connect or disconnect plentiful electricity by utilising small electricity, besides that the relay module is a switch that works using electromagnetic principles where when there is a weak flow flowing through the coil the soft iron core will become a magnet. The picture of the relay module circuit towards the lamp can be seen in Figure 2.

Arduino Uno R3 pin configuration with TCM 3105 FSK IC Modem is an Atmega328P-based board controller having six analogue inputs. Picture of the Arduino Uno R3 circuit against TCM 3105 FSK IC modem can be seen in Figure 4. The design of this tool aims to determine the overall set of tools. The design of this tool starts from the 220 Volt AC source to the 12 Volt DC power supply then to Steppdown DC or 5 Volt DC regulator. From the DC regulator to the breadboard circuit as a ground and 5V. For a series of websites connected by the internet where Arduino Mega as a controller and data processing unit of the ESP 8266 MCU node that receives data servers. The pin used on Arduino Mega to activate the relay module as follows: Pin A0: used in data in 4 for relay module 2. Pin A1: used in data in 3 for
relay module 2. Pin A2: used in data in 2 for relay module 2. Pin A4: used in data in 1 for relay module 2. Pin 22: used in data in 1 for relay module 1. Pin 24: used in data in 2 for relay module 1. Pin A8: used in data in 1 for relay module 3. Pin A9: used in data in 2 for relay module 3. Pin A10: used in data in 3 for relay module 3. Pin A11: used in data in 4 for relay module 3.

Then from the relay module, it is connected to an HPL LED of 24 pieces. These LEDs are connected in parallel in channels 1, 3, 5-9 and are arranged in series on channels 2 and 4. For frequency radio circuits, use TCM 3105 FSK IC modem as a modulator and Lupax brand's handy talkie as a receiver and transmitter. The receiver uses the Arduino Mega as the control unit, the TX and RX pins are used on tx data and RX TCM 3105 FSK IC modems. For HT the receiver is connected to the TCM 3105 FSK IC modem where the tx pin is used to the mic and from the speaker to RX pin. The transmitter circuit uses the Arduino Uno microcontroller as a data controller and processing unit from the digital keypad as shown in Figure 3.

For the interface of the radio frequency circuit using 16×2 LCD connected by i2c LCD. The pin used on Arduino Uno to activate the LCD that has been connected to i2c is Pin Vcc, Gnd, SDA, and Scl. Then the pins used on Arduino Uno to activate the digital keypad are as follows: Pin 4: used on data col 1 digital keypad. Pin 5: used on data col 2 digital keypad. Pin 6: used on data col 3 digital keypad. Pin 7: used on data col 4 digital keypad. Pin 8: used on data row 1 digital keypad. Pin 9: used on data row 2 digital keypad. Pin 10: used on data row 3 digital keypad. Pin 11: used on data row 4 digital keypad. In the transmitter circuit, it uses Arduino Uno as the controller unit whose TX and RX pins are used on TX and RX FSK IC TCM 3105 data modems.

3. Results and Discussion

The way to test the performance of the tool is from the beginning until the end of the process. The aim is to report that the device is working and that it can control the deadlights on public street lighting with digital buttons as an interface. One parameter of device performance is a delay. Delay is the time difference between the time the command input and the time the device has run the command [8]. For testing the lamp, data is taken for the time delay of data transmission from the sender and receiver. With a digital keypad, data delay taken with a certain distance illustrated in Figure 6.

From tests like the scenario above, each distance value test is performed ten times. ten experiments were carried out at each distance in meters so that the total experiment was 50 times. Of the 50 trials, there were 15 attempts whose connections were broken. Every ten experiments obtained an average delay of 1513 ms at a distance of 1 m, 2844 ms at a distance of 10 m, 4674 ms at a distance of 100 m, 4060 ms at a distance of 150 m and 3151 ms at a distance of 300 m as shown in Figure 7.

![Figure 6. System testing scenario](image)

Ten experiments were carried out 50 times at each distance in meters. Out of 50 trials, there were 13 times the connection was broken. Every ten tests obtained an average delay of 1523 ms at a range of 1 m, 3256 ms at a range of 10 m, 4694 ms at a range of 100 m, 4243 ms at a range of 150 m and 3881 ms at a range of 300 m as shown in Figure 8.
From testing with the switch on and switch off scenarios, we can compare the average delay value to the change in distance, as shown in Figure 9. Comparison of the average delay in the switch-on and switch-off conditions is different.

The average delay value is not significant. The anomaly occurs when the delay value at a distance of 100, 150, and 300. The delay value decreases because, at a range of 100, 150, and 300 connections are not connected. Under these conditions, the delay value considered empty (0) so that the average decreases. In the condition of the switch on at a distance of 100 m, the connection lost three times, at a distance of 150 m, the connection lost four times, and at a distance of 300 m, the connection lost four times.

Whereas in the case of a switch off at a distance of 100 m there were three times of disconnection, at a distance of 150 m there were four times of disconnection, and at a distance of 300 m, there were four times of disconnection.

![Figure 7. The average delay value in the switch-on condition](image1)

![Figure 8. The average delay value in the switch-off condition](image2)

![Figure 9. Comparison of average delay under switch-on and switch-off conditions](image3)

4. Conclusion

Conclusions of the results of the test design of radio frequency-based smart panel for public street lighting as follows:

- Design a radio frequency-based smart panel built using an Arduino microcontroller and MCU Node ESP 8266 with its frequency radio using FSK IC Modem 3105.
The performance of the device is running the control is measured by delay. Delay is the time difference between the time the command input and the time the device has run the command.

- The average delay is at an average distance of 1513 ms at a distance of 1 m, 2844 ms at a distance of 10 m, 4674 ms at a distance of 100 m, 4060 ms at a distance of 150 m and 3151 ms at a distance of 300 m.
- The delay value decreases because, at distances of 100, 150, and 300 m connections are lost. Under these conditions, the delay value is considered empty (0) so that the average decreases.
- The farther the distance, the higher the percentage of unconnected, this can be seen at distances of 100, 150, and 300 m.

Prototype angle accuracy testing to ensure the performance of prototype accuracy with bearing angle. Prototype runs according to trajectory and error does not until 90°.

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