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# Design of DCU Smart Lighting for Public Streetlights in Medan City

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**Abstract:** Currently, Medan City is developing a public streetlight project along the highways of Medan City. The Medan city government has spent billions to fix this. The construction of these public streetlights also consumes the city's electricity resources. Efficiency measures are needed to reduce the use of electricity for public streetlights. We propose this research using smart lighting technology. This device will detect human and vehicle movements, time settings, and step dimming that allows dynamic lighting and dimming. This technology also allows for communication from one device to another, such as if a pedestrian or car is detected, then the surrounding streetlights will turn on. This device will be equipped with PIR sensors, ultrasonic sensors, and light sensors. With the development of Internet of Things technology currently, it is expected to help control remotely and have an integrated system. The control and monitoring system is connected via the internet. The parameters to be controlled are the presence of humans, vehicles, and lighting, and all these parameters can be monitored with web-based and Android applications. Based on the above studies, this research will design a public streetlight system using a Data Control Unit (DCU) to facilitate the control system, and this device will be integrated with sensors such as human sensors (PIR), light sensors, and ultrasonic sensors. The system is in the form of smart lighting that can be monitored remotely, such as whether lights will be bright or dim if there are road users and vehicles, and each streetlamp will be connected to each other wirelessly.

**Keywords:** Smart Lighting, Sensor, DCU, Internet of Things (IoT)

## 1. Introduction

Currently, Medan city is building a public streetlights along the highways of Medan city [1]. The Medan city government has spent 25.7 Billions to fix the streetlights and sidewalks. These streetlights are very important, but they will consume a large portion of the city's electrical energy [2, 3]. According to research data, the forecast of electrical energy consumption in Medan City until 2030 will be 3,476.90 GWH or an increase of 5.99% every year [4]. The estimated use of electric power for the benefit of public streetlights until 2025 is 47.06 MW [5, 6].

Many steps for efficiency and saving electrical power on public streetlights have been carried out such as public streetlights using solar panels as a source of electricity [7]. Public streetlights integrated with lithium batteries [8]. public streetlights use sodium lamps with a step dimming switch system. public street lights use the public streetlights arrangement application [9, 10].

Technologies for saving and efficient use of electrical energy for streetlights are constantly evolving. These technologies vary depending on their features and customization requirements [11, 12]. Currently, the technology has led to smart lighting technology. These devices will detect human and vehicle movement, time settings, step dimming that allows dynamic lighting and dimming [13, 14]. This technology also makes it possible to communicate from one device to another, such as if a pedestrian or car is detected then the surrounding streetlights will turn on. The device will be equipped with

sensors and cameras [15, 16].

The addition of this technology will increase the benefits of public streetlights, namely saving and efficient use of electrical energy, increasing satisfaction for road users both pedestrians and motorized users, and facilitating the repair and maintenance process because the system is built in an integrated manner [17]. However, this is not free from shortcomings, namely a very large initial investment to convert a conventional system into a smart system. Further studies are needed on the public streetlights control system [18, 19].

By the development of Internet of Things technology at this time, it is expected to help control remotely and have an integrated system [20, 21]. The control and monitoring system is connected via the internet. The parameters to be controlled are the presence of humans, vehicles, lighting, and all these parameters can be monitored with web-based and android applications [22, 23].

Based on the above studies, this research will design a public streetlights system using a Data Control Unit (DCU) to facilitate the control system and this device will be integrated with sensors such as human sensors (PIR), light sensors, ultrasonic sensors. The system is in the form of smart lighting that can be monitored remotely, such as lights will be bright if there are road users and vehicles and each street lamp will be connected to each other wirelessly [24, 25].

Problem formulation in this research is how to develop smart lighting as an automatic public streetlights system that can be applied on public roads in Medan city [26]. DCU Smart Lighting is used as the main controller of the automatic street lighting system based on IoT technology [27, 28]. The communication network used for the process of sending data from the DCU smart lighting to the cloud server uses a GSM network [29, 30]. Using cloud server technology as a data storage medium for PIR sensors, light sensors, ultrasonic during the public streetlamp monitoring process. Using web-based and android applications as monitoring media on the user side [31, 32].

# 2. Method

### *2.1. Research Stages*

Literature research is explained through a fishbone diagram as shown in Figure 1. The DCU smart lighting system prototype is built with 6 main components, namely: Implementation consists of hardware design, software design, prototype testing and preparation of the final report. The parameters to be measured are object distance, vehicle distance, and lighting or weather conditions. Component requirements consist of smart lighting components, cloud servers, GSM communication modules. User-side programming in the form of websites and android. Sensor components consisting of PIR sensors, ultrasonic sensors, and light sensors.

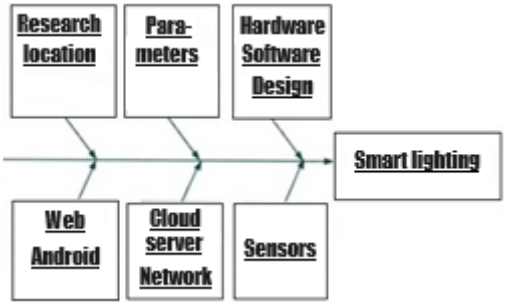


***Figure 1.*** *The Fishbone Diagram.*

### *2.2. Research Location*

The research location was conducted at the Telecommunication Laboratory of Politeknik Negeri Medan.

### *2.3. Research Model*

This research uses 3 sensors, namely light sensors, PIR sensors and ultrasonic sensors. The light sensor will detect the weather conditions around the public streetlamp. The parameters will be measured in the form of light intensity in lux units. If the weather is dark, the public street lights will automatically turn on in dim light conditions. However, if the ultrasonic sensor and PIR sensor detect vehicles and pedestrians, the public streetlights will turn on in brighter conditions. Conversely, if the weather conditions are brightly lit like during the day, then this system will not work temporarily (idle time).

This system is governed by the DCU smart lighting. This device is a multifunctional device that can be connected to several sensors and public streetlights in remote control because the device is equipped with LoRa and GSM wireless networks. The following is device of the DCU smart lighting as shown in Figure 2.

***Figure 2.*** *DCU Smart Lighting*

### *2.4. Research Design*

There are 5 main components, namely: the sensors are light sensor, ultrasonic sensor and PIR sensor. NB-cell (Narrow Band cell) is a LoRa device that is placed on the side of the public streetlamp. This device will send data from the sensors to the LoRa Gateway. LoRa Gateway is an interface to the GSM network to store sensor measurement data into the cloud server. Cloud server as a medium for storing measurement data Web-based and android applications as an interface to the user. The block diagram as shown in Figure 3.

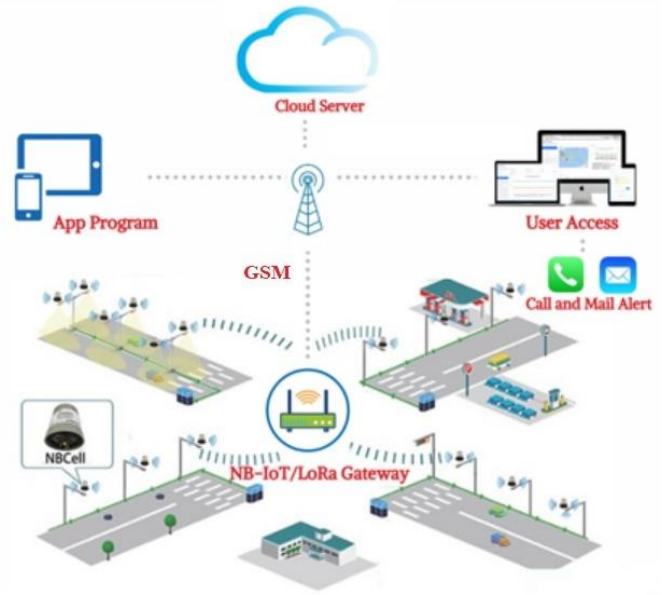


***Figure 2.*** *Block Diagram of research*

### *2.5. Data Collection and Analysis*

This system is to control public streetlights remotely and integrated. The parameters to be measured are the distance of human or pedestrian objects, the distance of vehicle objects and the light intensity around the public streetlights. All measured data will be stored centrally on the server. The network used for data transmission is a cellular network. This network can reach almost all regions in Indonesia, so that information or data on weather conditions, vehicle objects and humans, can be accessed online and the information can be seen in real-time.

This public streetlights control system, we can ensure savings and efficiency in the use of electrical energy, increase satisfaction for road users both pedestrians and motorized users, and facilitate the repair and maintenance process because the system is built in an integrated manner.

## 3. RESULTS

### *3.1. Testing of System*

***Table 1.*** *Testing of Ultrasonic Sensor with objects*

| No | Distance (m) | Status |
|---|---|---|
| 1 | 1,2 | OFF |
| 2 | 1,1 | OFF |
| 3 | 1,0 | ON |
| 4 | 0,9 | ON |
| 5 | 0,8 | ON |

***Table 2.*** *Testing of Light Sensor without objects*

| No | Time | Relay Status |
|---|---|---|
| 1 | Morning | OFF |
| 2 | Afternoon | OFF |
| 3 | Evening | OFF |

***Table 3.*** *Testing of Light Sensor with Objects*

| No | Time | Relay Status |
|---|---|---|
| 1 | Morning | OFF |
| 2 | Afternoon | OFF |
| 3 | Evening | ON |

***Table 4.*** *Testing of PIR Sensor with Objects*

| Object | Distance (m) | Switch Status |
|---|---|---|
| Human | 0.5 | ON |
| Human | 1 | ON |
| Human | 1.5 | ON |
| Human | 2 | ON |
| Human | 2.5 | ON |
| Human | 3 | ON |
| Human | 3.5 | ON |
| Human | 4 | ON |
| Human | 5 | ON |
| Human | 5.1 | OFF |

The ability of a smart lighting system to automatically inform about condition from a distance. Indications of on/off switch to streetlights can be seen by system. Then the data is sent using the internet network automatically. Needs analysis is carried out by analyzing component needs on general performance. This analysis was carried out to obtain the required specifications. The specifications in question are the required sensor components, Wi-fi module, processor and IoT platform. This public streetlights monitoring system can make it easier for officers to find out the condition of the lights at night.

This data storage server uses the internet of things platform with the website address. Next, the stored data is forwarded to an I/O platform (input output platform) in the form of graphs and indicators to present or display voltage and current data. This system requires an internet network connection. The processor module is used as a data communication network provider between processor and a web server.

Processor will manage and send data to cloud. The data processed includes data from the The sensors are light sensor, ultrasonic sensor and PIR sensor. The light sensor will detect the weather conditions around the public streetlamp. The parameters will be measured in the form of light intensity in lux units. If the weather is dark, the public street lights will automatically turn on in dim light conditions. if the ultrasonic sensor and PIR sensor detect vehicles and pedestrians, the public streetlights will turn on in brighter conditions. Conversely, if the weather conditions are brightly lit like during the day, then this system will not work temporarily (idle time).

There are several parameters that are measured, namely the

light intensity of the lamp, the distance of the object to the ultrasonic sensor, and the distance of the object to the PIR sensor. When planning lighting, there are things that need to be considered, traffic volume consisting of vehicles and related environments such as pedestrians, cyclists and so on.

### *3.2. Analysis*

The human body is always trying to maintain body temperature remains constant i.e. temperature normal human body is 37$^{o}$C even though it occur changes in environmental temperature. Arrangement temperature or thermal regulation is a regulation complex of a physiological process where there is equilibrium between heat production and loses heat so that body temperature can maintain constantly. Heat can be lost and enter the environment by convection, radiation, and evaporation.

Heat loss through radiation may occur if the temperature surrounding the object is very low. Convection heat loss occurs if the temperature surrounding the object is lower than at body temperature. This will greatly affect the measurement accuracy by the PIR sensor.

The way the PIR sensor system works is when someone walks past the sensor, the sensor will captures passive infrared rays emitted by the human body which has temperature which is different from the environment so that it causes Pyroelectric materials react to produce current electricity due to the heat energy carried by passive infrared rays. Then a existing amplifier circuit amplifies this current which is then compared by a comparator thus producing output.

## 4. Conclusion

The results of the sensor's work have a big influence on the smart lighting system as a comprehensive, because starting here this system will work intelligently. Furthermore, this research is intended to overcome the problems stated above, saving and efficient use of electrical energy, and this system helps security system during on the roads.

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