



Internet of Things (IoT) Based Temperature Monitoring System on The Low Voltage Sub-Distribution Panel (LVSDP) Busbar

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Abstract: In this study, a tool is designed to monitor the temperature on the busbar of the Low Voltage Sub Distribution Panel (LVSDP) based on the Internet of Things. This tool uses the internet network to receive data from a sensor in real-time. The tool in this study is designed to detect the heat generated by the busbars of each phase installed in the LVSDP. Real-time display on the smartphone provides notification if the temperature on the busbar has exceeded the preset set point. To monitor the temperature on the busbar, real-time monitoring is needed which will make it more convenient for technicians to carry out maintenance. Monitoring the temperature on this busbar will be carried out by utilizing technology from IoT which will be connected to the internet and integrated with smartphone devices. In this study, the authors will use the ESP32 module as a medium for receiving, storing, and displaying data on smartphone devices. ESP32 is a module often used for IoT projects. Equipped with Wi-Fi and Bluetooth features and has a Dual-Core Microprocessor which will make data processing faster. To be able to receive temperature data, an infrared MLX90614 sensor is needed. The MLX90614 infrared sensor is an electronic component that functions to detect heat without touching the object whose heat is to be measured because this sensor is facilitated with infrared light which can be directed at the object.

Keywords: LVSDP Busbar, IoT, MLX90614, Monitoring, Temperature, Internet of Things

1. Introduction

The development of technology in today's modern era, doing work is even easier. One of them is by utilizing the Internet of Things (IoT) as a medium to facilitate this work. Internet of Things (IoT) is a computing concept about everyday objects connected to the internet and able to identify themselves to other devices. The term "Internet of Things" consists of two main parts, namely the Internet which regulates connectivity and Things which means objects or

devices. In simple terms, a device that could collect data and send it to the Internet [1][2].

IoT can be connected to many things, one of which is in the electricity sector which will make work easier. In distributing electricity to homes or to industries for low voltage, a Low Voltage Sub Distribution Panel (LVSDP) is needed which functions as the main divider for the distribution of installation power throughout the building and its surroundings.

One of the main components in LVSDP which has a very important role is the busbar. Busbars are bare conductors in the form of metal plates, namely copper (Cu) which have a certain size (according to the needs of the panel) whose function is the same as cables in general, namely, to conduct electricity to each electrical component on the panel. As a medium conductor of electric current, of course the busbar will experience heating which will affect the age of other electrical components.

The temperature monitor on the busbar, real-time monitoring is needed which will make it easier for technicians to carry out maintenance. Monitoring the temperature on this busbar will be carried out by utilizing technology from IoT which will be connected to the internet and integrated with smartphone devices. In this study, the authors will use the ESP32 module as a media for receiving, storing and displaying data to smartphone devices. ESP32 is a module often used for IoT projects. Equipped with Wi-Fi and Bluetooth features and has a Dual-Core Microprocessor which will make data processing faster. To be able to receive temperature data, an infrared sensor MLX90614 is required. The MLX90614 infrared sensor is an electronic component that functions to detect heat without touching the object whose heat is to be measured because this sensor uses infrared light directed at that object.

1.1 Low Voltage Sub Distribution Panel (LVSDP)

Low Voltage Distribution Panel is a combination of one or more low voltage circuit equipment with control equipment, measuring equipment, safety and control which are interconnected. The whole is assembled complete with the wiring and mechanical systems on the supporting parts.

The maximum number of directions per transformer or distribution substation is 8, according to the power of the transformer and the Current Carrying Capability of the LVN (Low Voltage Network) conductors used. The LVSDP must include a one-line diagram, the rated current of the protective and control devices and the name of the LVN route [2][3][4].

LVSDP is installed on the low voltage or transformer secondary side of a distribution substation, whether it

is a Concrete Substation, Kiosk Substation, Portal Substation or Cantol Substation. LVSDP function as a liaison and divider or distribution of electric power from the output of the secondary side transformer (TR) to the dividing rail and forwarded to the low voltage network via the mains cable (Opstyg Cable) which is secured by the respective mains fuse.

1.2 Construction of Low Voltage Sub Distribution Panel

a. Incoming Unit



Figure 1. Incoming Unit LVSDP [2]

The input unit is a functional unit intended to supply electricity to the LVSDP. The input unit circuit is provided with a three-pole load-breaker designed for a nominal voltage of 500 V with visible disconnecting units or with disconnecting units in an enclosed box with an open/close position indicator for which reliability can be guaranteed. For cable connections from the transformer must be equipped with a connecting plate or terminal [5].

b. Outgoing Unit

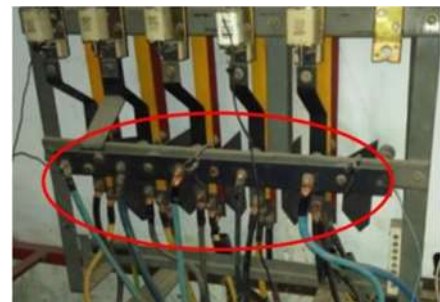


Figure 2. Outgoing Unit of Low Voltage Sub Distribution Panel (LVSDP)

The input unit is a functional unit intended to supply electricity to the LVSDP. The input unit circuit is provided with a three-pole load-breaker designed for a nominal voltage of 500 V with visible disconnecting units or with disconnecting units in an enclosed box with an open/close position indicator for which reliability can be guaranteed. For cable connections from the transformer must be equipped with a

connecting plate or terminal. The amount of current flowing on the busbar rail must be calculated according to the ability of the rail so that it will not cause a temperature of more than 65°C [6].

1.3 Internet of Things (IoT)

The Internet of Things (IoT) can be described as the capability of multiple devices to communicate, connect, and exchange data over the internet network. It serves as a communication technology enabling control, collaboration, and data communication among various hardware devices via the internet. In essence, IoT involves connecting non-human-operated things to the internet [2][7].

There are numerous advantages to utilizing the Internet of Things (IoT), and some of them are as follows:

- a. **Connectivity:** IoT allows people to operate multiple things from a single device, such as smartphones.
- b. **Efficiency:** The increased connectivity results in reduced time spent on repetitive tasks.
- c. **Convenience:** IoT devices are becoming increasingly common and widely owned by most people [8].
- d.

1.4 Atmega and AVR's Tisc Processor (AVR)

Microcontroller Atmega and AVR's Tisc Processor or often abbreviated as AVR is an 8-bit RISC microcontroller. It is because of RISC that most of the instruction code is packed into one clock cycle. AVR is the type of microcontroller most often used in electronics and instrumentation [9].

1.5 ESP32 Module

ESP32 is a microcontroller introduced by Espressif System which is the successor of the ESP8266 microcontroller. This microcontroller already has WiFi and Bluetooth modules on the chip, so it is very supportive for creating Internet of Things application systems [10]. The appearance of the ESP32 module is as follows:



Figure 3. ESP 32 Module [11]

The basic features of the ESP32 module are as follows:

- Number of pins: 30 including voltage and GPIO pins
- 15 pin ADC (Analog to Digital Converter)
- 3 UART Interfaces
- 3 SPI Interfaces
- 2 I2C Interfaces
- 16 pins PWM (Pulse Width Modulation)
- 2 pin DAC (Digital to Analog Converter)

1.6 An Infrared Temperature Sensor MLX90614

The MLX90614 sensor is an infrared thermometer utilized for non-contact temperature measurements of objects. This sensor comprises an infrared-based temperature-sensitive detector chip and an ASSP signal conditioner, both integrated within the TO-39 package. Additionally, it features a low noise amplifier, 17-bit ADC, DSP unit, and a highly accurate and precise thermometer [11].

To calibrate the thermometer, digital outputs from the PWM and SMBus are employed. The 10-bit PWM standard allows for continuous temperature monitoring within a sensor temperature range of 40°C to 120°C. Furthermore, the sensor can measure object temperatures spanning from -70°C to 380°C, with an output resolution of 0.14°C. For a visual representation of the MLX90614 temperature sensor's circuit and physical appearance, refer to Figure 4.



Figure 4. Figure of Infrared Sensor MLX90614 [2]

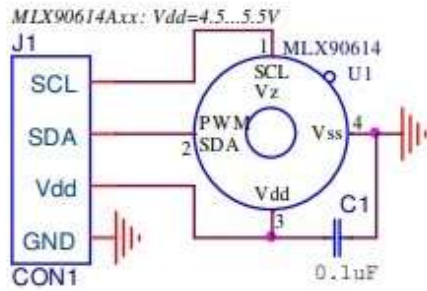


Figure 5. Circuit Schematic of Temperature Sensor MLX90614 [2]

The PWM pin can be used as a temperature change relay (To as input), which is easy and cheap to use in a thermostat or temperature warning (freezing or boiling) use. In SMBus, this feature can function as an interrupt to the processor which can trigger the reading of all slaves on the bus and determine the actual conditions.

Normally, the MLX90614 sensor can sense objects with an emissivity value of 1. However, this sensor can be easily calibrated to sense objects with an emissivity value of 0.1 to 1 [12].

1.7 LCD 16x2

The 16x2 LCD is an electronic component consisting of a liquid crystal display which is used to display output data in the form of letter and number characters. The LCD has 16 columns and 2 rows which can display 32 characters in the form of a dot matrix. Each character consists of dots measuring 5x8 pixels. Therefore, a 16x2 LCD has a total of 1280 pixels. LCD can work in 4 bit and 8-bit mode. The LCD works with a voltage between 4.7 V and 5.3 V. The following is the physical appearance and arrangement of the pins on the LCD in Figure 6.



Figure 6. LCD I2C [6]

As shown in Figure 2.11, the LCD has 4 pins, the way to connect these pins to Arduino is as follows:

- a. The SDA pin is connected to Arduino's A4 analog pin.
- b. The SCL pin is connected to Arduino analog pin A5.

- c. The VCC pin is connected to Arduino's 5V pin.
- d. The GND pin is connected to one of Arduino's GND pins [6].

1.8 Power Supply

A power supply is a vital device that furnishes electrical energy to one or more electrical loads. It plays a crucial role in electronics, serving as a source of electric power, such as in batteries. The power supply circuit primarily comprises a transformer, rectifier, and voltage smoothing components. While the term is commonly associated with devices that convert one form of electrical energy to another, it can also encompass devices that transform other forms of energy, such as mechanical, chemical, or solar, into electrical energy.

When creating a power supply circuit, it is essential to incorporate not only the main components but also supporting elements to ensure the circuit functions effectively. Two types of power sources are available: AC source and DC source. The DC source is derived from the AC source through a rectifier circuit formed with diodes. Meanwhile, in the AC source, the voltage oscillates between positive and negative poles [8].

A well-designed power supply circuit, equipped with the necessary components, allows for the smooth transformation and supply of electrical energy, ensuring optimal performance in electronic devices and systems [13].

2. Research Methods

2.1 Process Flowchart

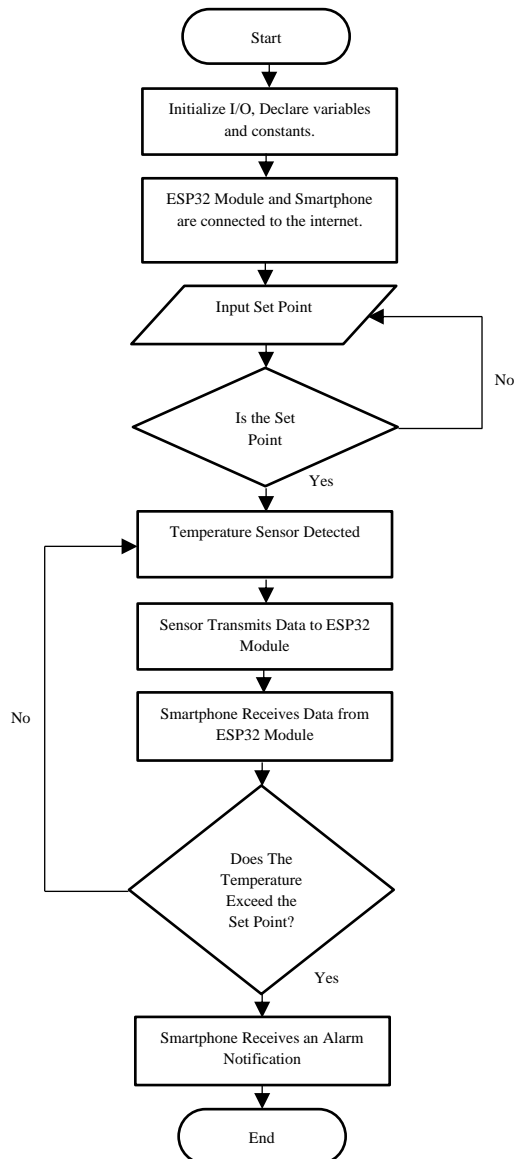


Figure 7. Data Collection Process Flowchart

2.2 Methods

This research employs a method to gather temperature data from the Low Voltage Sub Distribution Panel (LVSDP) at PT. PLN ULP Ampera, utilizing Internet of Things (IoT) based monitoring. The data collection process involved three steps as follows:

1. Firstly, the MLX90614 sensor was brought close to each busbar, maintaining approximately 5 cm.
2. Subsequently, temperature data for each phase of the busbar was recorded on an hourly basis, starting from 09:00 to 17:00. This measurement

was repeated three times, with a set point temperature of 50°C.

3. The monitoring system was programmed to raise an alarm through the Blynk application if the temperature exceeded the predefined set point limit.

The overall performance of the system was evaluated to ascertain the effectiveness of the LVSDP busbar temperature monitoring system. The hardware devices were positioned in the LVSDP panel situated at the distribution substation. Using the monitoring system application, the recorded data was displayed along with emergency notifications in the event of overheating, specifically when the temperature surpassed the predetermined set point.

The specifications of the distribution substation used as a place for data collection are as follows:

Table 1. Specification of Distribution SubStation

Nu. Station	U.601 / PD.672
Serial Number	2016 1245
No. SPLN	SPLN D3.016-1: 2010
Trafi Capacity	200 kVA
Voltage Rating	400 V
Current Rating	250 A
Type	PL-250-2-LBS
Bus	2 Bus



Figure 8. Lay Out of The Equipments

1. Bring the MLX90614 sensor closer to each busbar which can be seen in Figure 5 with a distance of approximately 5 cm.
2. Then the data to be taken is the temperature of each phase of the busbar recorded hourly starting

from 09.00 to 17.00 and repeated 3 measurements with the set point set at 50 °C.

3. If the temperature exceeds the set point limit, a warning notification will be obtained on the blynk application as shown in figure 9 below



Figure 9. Display of The Tool When detecting excessive temperature



Figure 10. Alarm on Smartphone

3. 3.2 Analysis of Measurement Data

The data presented is based on the temperature measurements obtained from the MLX90614 sensor on the busbar at LVSDP. The device's set point is configured at 50°C, and if the measured temperature reaches this set value, a warning notification will be triggered, as depicted in Figure 8. The data collection process took place at the distribution substation situated at PT. PLN ULP Ampera, conducted from 09:00 to 17:00, over three instances. Subsequently, the heat generated on the busbar was derived from the results obtained on these three measurement days [13] [14].

On the initial measurement day, utilizing the sensors, the highest recorded temperature on the busbar occurred between 13:00 and 14:00, specifically during the R phase, reaching 43.33°C. Continuing with the second measurement day, again using sensors, the highest temperature on the busbar was observed between 13:00 and 14:00, in the T phase, at 52.45°C. In

this situation, the monitoring tool is activated to deliver a notification signal to the connected cellphones. Lastly, on the third measurement day, employing sensors, the highest temperature on the busbar was registered between 13:00 and 14:00, within the T phase, at 43.79°C.

Based on the acquired data, it is evident that the temperature on the busbar at LVSDP PT. PLN ULP Ampera remains well within safe limits [15]. The maximum temperature recorded by the sensor stands at 52.45°C, which is still in accordance with PLN standards, where the permissible maximum temperature for busbars is set at 65°C. Notably, to demonstrate the efficacy of the monitoring system, the authors set the device's set point to 50°C. This configuration allowed for the reception of warning notifications via the blynk application on a smartphone, as demonstrated on the second measurement day, when the busbar temperature exceeded 50°C, promptly triggering a warning notification, as depicted in Figure 10.

3. Results and Discussion

3.1 Tables of Measurement

Table 2. Result of Temperature Measurement Day 1

Waktu	Set Point = 50 °C	Suhu (°C)		
		Fasa R	Fasa S	Fasa T
09.00-10.00		29,57	29,37	29,45
10.00-11.00		32,89	32,73	32,41
11.00-12.00		35,15	35,62	35,83
12.00-13.00		38,52	38,81	38,24
13.00-14.00		43,33	43,17	42,58
14.00-15.00		40,12	40,95	39,42
15.00-16.00		38,45	36,85	37,05
16.00-17.00		36,17	35,57	35,21

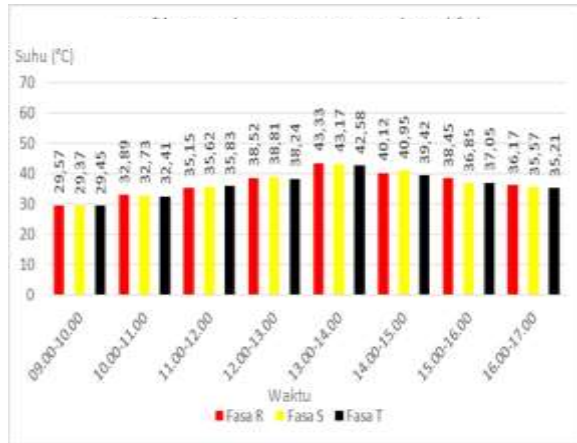


Figure 11. Graphic of Temperature Measurement Day 1

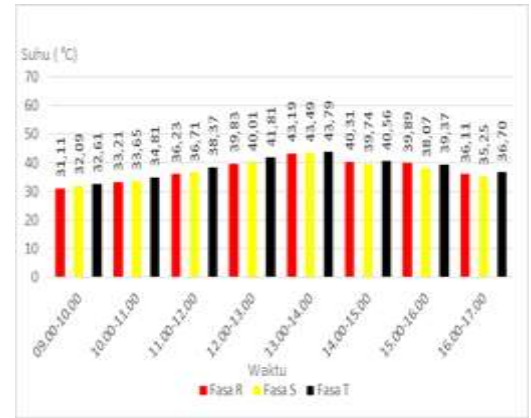


Figure 13. Graphic of Temperature Measurements Day 3

Tabel 3. Result of Temperature Measurement Day 2

Waktu	Set Point = 50 °C	Suhu (°C)		
		Fasa R	Fasa S	Fasa T
09.00-10.00		31,19	31,43	31,05
10.00-11.00		34,15	33,87	32,69
11.00-12.00		40,01	38,71	40,39
12.00-13.00		45,71	44,11	44,63
13.00-14.00		49,13	49,03	52,45
14.00-15.00		45,59	46,59	48,42
15.00-16.00		41,09	42,49	43,75
16.00-17.00		37,27	37,67	38,13

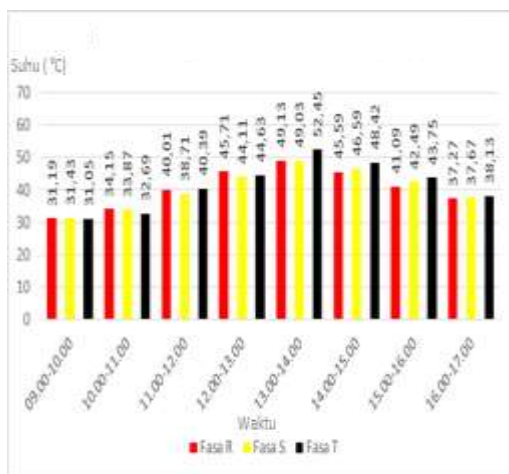


Figure 12. Graphic of Temperature Measurements Day 2

Tabel 4. Result of Temperature Measurement Day 3

Waktu	Set Point = 50 °C	Suhu (°C)		
		Fasa R	Fasa S	Fasa T
09.00-10.00		31,11	32,09	32,61
10.00-11.00		33,21	33,65	34,81
11.00-12.00		36,23	36,71	38,37
12.00-13.00		39,83	40,01	41,81
13.00-14.00		43,19	43,49	43,79
14.00-15.00		40,31	39,74	40,56
15.00-16.00		39,89	38,07	39,37
16.00-17.00		36,11	35,25	36,70

4. Conclusion

Based on the conducted design, testing, and data collection, the final report reveals the following conclusions:

1. LVSDP at PT. PLN ULP Ampera operates at a rated voltage of 400 V and a rated current of 250 A, featuring two types of busbars.
2. The maximum recorded temperature from sensor measurements is 52.45°C.
3. During data collection, the set point was configured to 50°C. Consequently, if the busbar temperature surpasses this set point, the system will promptly issue a warning notification through the blynk application.
4. The percentage of the highest error rate, calculated from the comparison between the two sets of measurement data, is 5.56%.

These conclusions are drawn based on the comprehensive design, testing, and data analysis, providing valuable insights into the performance and behavior of LVSDP at PT. PLN ULP Ampera, while also highlighting the temperature threshold and monitoring system in place to ensure optimal functionality and safety.

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