

Voltage and Current Monitoring System of Neon Box Lamps at the Electrical Engineering Building

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Abstract

The neon box monitoring system at the electrical engineering building is designed to provide real-time monitoring of outdoor lighting. This system aims to monitor the operational conditions of the neon box, including parameters such as voltage and current, to ensure stable performance and energy efficiency. The ESP32 microcontroller is used as the main controller, integrated with various sensors such as the PZEM-004T for electrical measurement. Data from each sensor node are transmitted via the internet network. All received data are stored in a database and visualized through the Blynk dashboard, allowing users to monitor neon box power consumption remotely. In addition, the system is equipped with an automatic notification feature that sends alerts to maintenance personnel via the Blynk application. The implementation of this monitoring system improves maintenance efficiency and reduces downtime. The reading results of the PZEM-004T AC voltage sensor show an average reading error of 0.66%, while the AC current readings show an average error of 2.53%.

Keywords : Lighting, integrated, sensors, and downtime.

1. INTRODUCTION

The rapid advancement of technology, particularly in the field of the Internet of Things (IoT), has enabled various systems to be monitored and controlled remotely with greater accuracy and efficiency. One area that benefits from this development is the management of outdoor lighting systems, such as neon boxes used for signage and information displays in public and institutional buildings. At the Electrical Engineering Building of Politeknik Negeri Bengkalis, the neon box serves not only as an identification sign but also as a representation of the department's technological image. Therefore, maintaining its continuous operation and energy efficiency is crucial.

Traditional monitoring methods that rely on manual inspection are inefficient and often result in delayed detection of failures, such as power outages, overheating, or irregular current consumption. To overcome these limitations, a monitoring system based on IoT technology is developed to provide real-time supervision of the neon box's electrical parameters, including voltage and current.

This system uses an ESP32 microcontroller as the main control unit, equipped with a PZEM-004T sensor for electrical measurement and connected to the Blynk IoT platform for data visualization and notification. Through this platform, users can remotely monitor the status of the neon box and receive automatic alerts when abnormal conditions occur. The implementation of this monitoring system is expected to enhance maintenance efficiency, minimize downtime, and support sustainable energy management at the Electrical Engineering Building of Politeknik Negeri Bengkalis.

2. REVIEW OF LITERATURE

The concept of remote monitoring has evolved significantly with the integration of Internet of Things (IoT) technology, which allows real-time data collection and control through interconnected devices. IoT-based systems have been widely adopted in various applications, including smart homes, industrial automation, and energy management (Norouzzadeh et al.,

2025). In these systems, microcontrollers such as ESP8266 and ESP32 play a crucial role in collecting sensor data and transmitting it to cloud platforms via Wi-Fi or other communication protocols (Elhattab & Elatar, 2024; Morchid et al., 2025).

Several studies have explored the implementation of IoT for monitoring electrical parameters. For example, Muksin & Tjahjono developed an IoT-based power monitoring system using the PZEM-004T sensor to measure voltage, current, and power consumption, displaying the data on the Blynk platform for remote access (Muksin & Tjahjono, 2025). Similarly, Geraldine et al. (2024) designed a smart lighting system that automatically controls and monitors energy usage through IoT integration, demonstrating improved efficiency and reduced maintenance costs (Geraldine et al., 2024).

The ESP32 microcontroller has become a preferred choice due to its dual-core processor, integrated Wi-Fi and Bluetooth, and compatibility with various sensors (Surani et al., 2025). Additionally, the Blynk IoT platform provides an efficient and user-friendly interface for real-time data visualization and notifications, making it suitable for remote monitoring applications (Esmeralda et al., 2025).

From these previous studies, it can be concluded that IoT-based monitoring systems are reliable and effective for managing electrical devices remotely. Therefore, adopting a similar approach for monitoring the neon box at the Electrical Engineering Building of Politeknik Negeri Bengkalis is expected to improve system reliability, ensure energy efficiency, and support proactive maintenance strategies.

3. METHOD

This study employs an experimental research approach with an emphasis on IoT-based system design and implementation. The experimental method was chosen because it allows the researcher to directly test the functionality and performance of the developed system under controlled and real operating conditions. The research involves the process of designing, assembling, programming, and testing the Neon Box Monitoring System to evaluate its accuracy, reliability, and efficiency. The experiment aims to verify whether the system can monitor electrical parameters such as voltage and current, in real time and provide automatic notifications through the Blynk platform.

This type of research is applied experimental research, as it combines theoretical knowledge of microcontroller-based systems and IoT communication with practical application in the field. The results are expected to produce a functional prototype that can be implemented as a real monitoring solution in the Electrical Engineering Building.

The research was conducted at the Electrical Engineering Building of Politeknik Negeri Bengkalis, located in Bengkalis Regency, Riau Province, Indonesia. This site was selected because it represents a real environment where electrical energy monitoring and management are essential. The building features a neon box that operates as an identification sign and a visual representation of the department, which requires continuous operation and energy efficiency.

The installation point for the monitoring device was placed near the neon box's power source to facilitate accurate measurement of voltage and current. The site conditions also allowed stable Wi-Fi connectivity, enabling the ESP32 microcontroller to communicate seamlessly with the Blynk cloud server. Field testing at this location ensured that the system could perform effectively under actual environmental and operational conditions.

The equipment and materials used in this study are essential components that support the design, implementation, and testing of the IoT-based Neon Box Monitoring System. Each item plays a specific role in ensuring accurate data acquisition, reliable communication, and real-time monitoring. The detailed explanation is as follows:

1. ESP32 Microcontroller

The ESP32 serves as the main control unit of the system. It features a dual-core processor, built-in Wi-Fi and Bluetooth connectivity, and multiple GPIO pins for sensor integration. The ESP32 is responsible for reading data from the connected sensors, processing the information, and transmitting it to the Blynk IoT platform over a wireless network. Its high processing speed and low power consumption make it ideal for real-time IoT monitoring applications.

2. PZEM-004T Module

This module is used to measure electrical parameters, including voltage (V), current (A), power (W), energy (Wh), and frequency (Hz). It communicates with the ESP32 using the UART (serial communication) protocol. The PZEM-004T provides precise readings, allowing accurate analysis of the neon box's electrical performance and energy consumption.

3. Wi-Fi Network

A stable Wi-Fi connection is used as the communication medium between the ESP32 microcontroller and the Blynk cloud server. This allows real-time data transmission, ensuring that users can remotely access system information via the Blynk mobile application or web dashboard.

4. Liquid Crystal Display I2C 20x4

The LCD is used to display sensor data, including voltage, current, power, and electrical energy consumed by the neon box lamp at the Electrical Engineering Building of Politeknik Negeri Bengkalis.

5. Blynk IoT Platform

The Blynk platform serves as the cloud-based interface for data visualization and notification. It displays real-time sensor readings (voltage, current, power) through gauges and graphs. It also provides automatic alert notifications to maintenance personnel when abnormal conditions occur, such as power loss, overcurrent, or overheating.

6. Power Supply (5V DC)

A regulated 5V DC power supply is used to provide stable electrical power for the ESP32 microcontroller and the connected sensors. Proper voltage regulation ensures system stability and prevents damage to electronic components during operation.

7. Wiring Components and Connectors

These include jumper cables, terminal blocks, and protective enclosures. They are used to connect and secure all hardware components, ensuring reliable electrical connections and safety from environmental factors such as dust and moisture.

Through the combination of these components, the system is capable of performing continuous data acquisition, wireless data transmission, and remote monitoring of the neon box's operational status, ensuring an effective and efficient IoT-based monitoring solution.

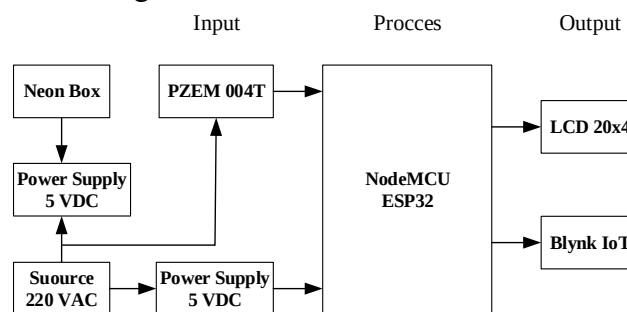


Fig. 1. Block Diagram System

The working system of the electrical power consumption monitoring system for the neon box in the Electrical Engineering Department can be seen in Fig. 2.

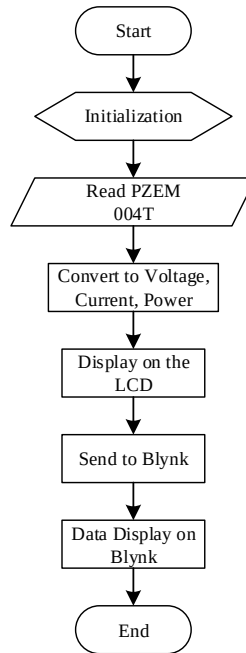


Fig. 2. Device Working System Flowchart

Based on Fig. 2, it can be explained that when the system starts operating, initialization of inputs and outputs is performed, including the PZEM-004T sensor input and the I2C LCD output. Next, the PZEM-004T sensor reads the voltage, current, and power consumption data of the neon box lamp. The data read by the NodeMCU ESP32 is then displayed on the LCD and transmitted to Blynk IoT, allowing it to be monitored online.

The Blynk IoT Display Design is used to monitor the voltage, current, power, and electrical energy consumed by the neon box lamp. The monitoring interface is created through the official website: <https://blynk.cloud/dashboard/login>. The first step is to log in to a registered account. Then, for displaying voltage, current, and power, the gauge type is used, while for displaying electrical energy consumption, a numeric label is utilized. The next step involves configuring the datastream to determine the maximum data values to be used. The Blynk IoT interface design can be seen in Fig. 3.

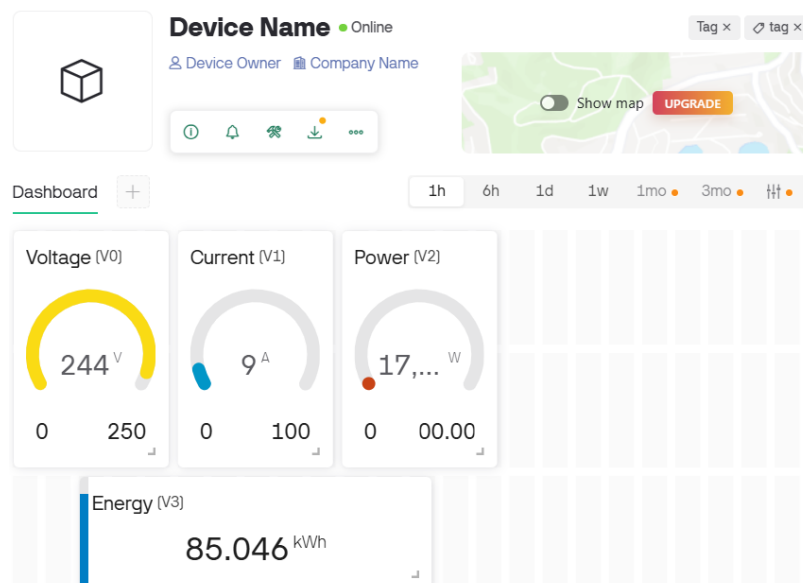


Fig. 3. Blynk IoT Interface Design

4. RESULT & DISCUSSION

Blynk IoT Design Results

The design results display the interface of an IoT-based electrical monitoring system, likely using the Blynk IoT platform. Several display panels are available on this platform, including:

1. The “Voltage (V0)” panel, colored yellow, shows an electrical voltage of 245 V within a measurement range of 0–250 V.
2. The “Current (V1)” panel, colored blue, displays an electric current of 60 A within a range of 0–100 A.
3. The “Power (V2)” panel, colored gray with a red indicator, shows an electrical power value of 35.99 W within a range of 0–100,000 W.
4. The “Energy (V3)” panel, located at the bottom, displays the total electrical energy consumed, amounting to 91.997 kWh.

Overall, this figure illustrates the results of real-time monitoring of electrical parameters (voltage, current, power, and energy) through an IoT dashboard, typically connected to sensors such as PZEM-004T and a ESP32 microcontroller.

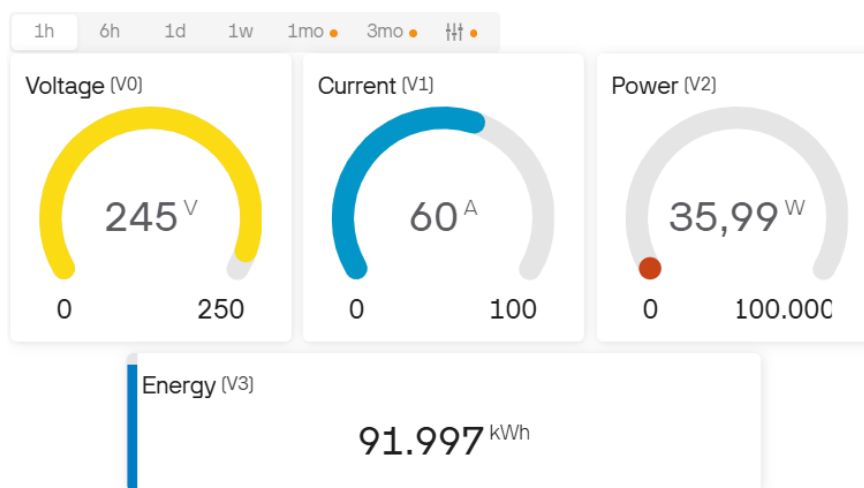


Fig. 4. Blynk IoT Design Results

PZEM 004T Voltage Testing Results

The voltage testing was carried out by comparing the readings of the PZEM-004T voltage sensor with a factory-calibrated voltmeter. The test was conducted five times using various voltage levels adjusted with an adjustable AC voltage regulator. The results of this test are shown in Table 1.

Table 1. Comparison Between PZEM-004T Voltage Sensor and Voltmeter

Voltage Sensor PZEM 004T (V)	Voltmeter (V)	Error (%)
168,8	168,85	0,03
195,3	192,77	1,31
216,7	218,67	0,90
227,9	229,12	0,53
243,4	242,17	0,51
Average		0,66

The analysis results in Table 1 show that within the measurement range of 168.8–243.4 V, the sensor has an average measurement error of 0.66%, which is still within the acceptable tolerance limit. The voltage measurement error can be caused by several factors. First, the internal accuracy of the voltage sensor itself has limitations influenced by the quality of electronic components such as voltage divider resistors and the analog to digital converter (ADC) circuit on the microcontroller. Second, electrical interference or noise in the AC voltage source can cause fluctuations in the readings, especially if the system is not equipped with filters or noise-suppressing capacitors. Third, improper sensor calibration can also lead to deviations between the measured values and the actual values.

PZEM 004T Current Testing Results

The current testing was carried out by comparing the readings of the PZEM-004T current sensor with a factory-calibrated ammeter. The test was conducted five times using an incandescent lamp with variations in electrical power. The results of this test are shown in Table 2.

Table 2. Comparison Between PZEM-004T Current Sensor and Ammeter

Current Sensor PZEM 004T (A)	Amperemeter (A)	Error (%)
0,12	0,122	1,64
0,18	0,188	4,26
0,25	0,259	3,47
0,36	0,367	1,91
0,42	0,422	0,47
Average		2,35

The analysis results in Table 2 show that within the current measurement range of 0.12–0.42 A, the sensor has an average measurement error of 2.35%. This value indicates that the sensor's accuracy is still considered good for low-power current monitoring applications. The current measurement error can be caused by several factors. First, the accuracy of current measurement components, such as current transformers or hall-effect-based sensors, has certain tolerance limits that can cause differences between the actual and measured values. Second, electromagnetic noise from the surrounding environment or from inductive loads (such as electric motors or lamp ballasts) can interfere with the measured current signal, especially in systems without proper shielding. Third, calibration errors in the measuring instrument or imprecise analog-to-digital (ADC) signal conversion in the microcontroller can further contribute to deviations in the measurement results.

5. CONCLUSION

Based on the results and tests conducted, it can be concluded that the Blynk IoT interface design is capable of displaying four parameters: voltage, current, electrical power, and electrical energy consumed by the neon box lamp in the Electrical Engineering Building. The reading results of the PZEM-004T AC voltage sensor show an average reading error of 0.66%, while the AC current readings show an average error of 2.53%.

6. ACKNOWLEDGEMENTS

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