Design of an Electrical Power Monitoring and Alert System Based on Internet of Things (IoT) for Chicken Coops

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Abstract -- The reliability of the electricity supply is a vital factor in ensuring the sustainability of modern poultry farming systems. Power outages or electrical disturbances can disrupt ventilation, heating, and lighting systems, resulting in decreased productivity on poultry farms. This study aims to design an Internet of Things (IoT)-based power supply detection and early warning system to monitor electrical conditions in real-time and provide automatic notifications to farmers. The system was developed using a ZMPT101B voltage sensor, an ACS712 current sensor, and a NodeMCU ESP8266 microcontroller, all of which are connected to the Blynk platform for notification delivery. The research employed a prototyping approach, consisting of five stages: communication, planning, design, construction, and implementation. Testing was conducted in a closed poultry house located in Wonolopo, Mijen, Semarang City. The results showed that the system was able to detect power disturbances with an accuracy rate of 97.6% and a notification response time of less than 3 seconds. The system proved effective in providing early warnings to farmers and enhancing the operational safety of electricity-based poultry farms.

Keywords-- Internet of Things, Power Detection, Early Warning, Poultry House, Smart Farming

1. Introduction

Modern poultry farming systems rely heavily on electrical energy to ensure proper environmental control, including temperature regulation, ventilation, and lighting. These parameters are critical for maintaining the health, growth, and productivity of poultry [1]. Any interruption in power supply can cause significant disruptions to these systems, leading to stress among the chickens, reduced feed efficiency, slower growth rates, and in severe cases, increased mortality [2]. As the poultry industry increasingly adopts automation and smart control systems, ensuring the reliability and continuity of electrical power becomes a vital operational requirement.

Power outages and electrical instability are common challenges faced by poultry farms, especially in developing regions where power grids may be unreliable. Such disturbances can cause the failure of heating systems for chicks or the malfunctioning of ventilation fans in closed-house systems, both of which can rapidly endanger flock health [3]. Therefore, early detection of electrical anomalies and timely alerts to farmers are essential to prevent potential losses and ensure smooth farm operations [4].

In recent years, the Internet of Things (IoT) has emerged as a promising technological approach for real-time monitoring and control across various sectors, including agriculture and livestock management. IoT systems enable the integration of sensors, microcontrollers, and communication platforms that allow users to remotely monitor power conditions [5], environmental parameters, and equipment status [6]. In the poultry sector, IoT applications have been developed for temperature and humidity monitoring, feed and water management, and environmental control. However, studies focusing on power supply monitoring are still limited in scope, often emphasizing data logging and visualization rather than real-time alert mechanisms or automatic fault detection [7].

To address these limitations, an IoT-based power supply detection and early warning system is proposed in this study. The system is designed to continuously monitor voltage and current levels using sensors and to send automatic notifications to farmers when irregularities or power outages occur. By providing real-time alerts through mobile devices [8], the system helps farmers take immediate corrective actions, thus minimizing the risk of operational failures in electricity-dependent poultry houses.

This study specifically aims to (1) design an IoT-based detection and warning system for monitoring power supply in poultry houses, (2) develop an automated notification mechanism integrated with mobile applications, and (3) evaluate the system's performance and reliability in detecting electrical disturbances under real-world farm conditions. The expected outcome of this research is an effective, low-cost solution that enhances the operational safety and productivity of smart poultry farms.

2. Literature Review

The application of the Internet of Things (IoT) in the energy and livestock sectors has gained significant attention in recent years due to its potential to improve efficiency, reliability, and sustainability [9]. IoT-based systems enable continuous data acquisition, remote monitoring, and intelligent control, allowing users to make timely and data-driven decisions. In the context of electrical power management [8], IoT has been utilized to monitor voltage stability, detect outages, and automate energy distribution processes in both industrial and agricultural environments.

Several studies have explored the use of IoT technologies for early warning and monitoring of power supply disruptions. [10] Developed an IoT-based alert system capable of notifying users of power failures through a mobile interface. Similarly, [11] Designed a prototype for monitoring electrical conditions in rural areas to prevent equipment damage caused by unstable power. While these systems successfully demonstrated the feasibility of IoT for power anomaly detection, most of them were limited to monitoring and alerting functions without integrating automatic backup activation or predictive analysis capabilities.

Building upon these previous works, the present study aims to enhance IoT-based power monitoring systems by incorporating real-time detection, automated power backup activation, and cloud-based mobile integration. This approach not only addresses the limitations found in earlier studies but also provides a more comprehensive solution suitable for electricity-dependent poultry farms. The integration of mobile and cloud platforms allows farmers to receive instant notifications and access power condition data remotely, thus improving responsiveness and operational safety.

3. Research Methods

This study employed an experimental research approach to design, develop, and evaluate an IoT-based electricity supply detection and warning system for poultry houses. The methodology was structured to ensure that each stage, from system design to field testing, accurately represented real operational conditions in poultry farming environments. The research process consisted of three main components: (1) defining the research location and overall design framework, (2) developing the IoT-based monitoring system, and (3) testing and evaluating the system's performance under various electrical conditions.

The development process followed a prototyping model, which involves iterative stages of observation, planning, designing, manufacturing, and testing [12]. Each stage is interrelated and allows continuous refinement of the system based on evaluation results and user feedback. The overall flow of the development process is illustrated in Figure 1, which shows the cyclic relationship among the five key stages of the prototyping methodology.

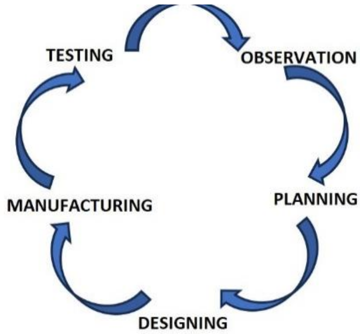

Fig 1. The prototyping model used in system development.

Figure 1 presents the research methodology, which consists of five stages: observation, planning, designing, manufacturing, and testing. The observation stage was carried out at the fungus house, where the environmental and electrical conditions were examined to determine the system requirements. During the planning stage, the necessary hardware components, devices, and software platforms for system development were identified and organized to ensure compatibility and functionality in subsequent stages.

3.1 Observation

The observation stage aimed to identify real conditions and challenges related to the reliability of electricity supply in poultry farms. Field observations were conducted at a closed poultry house located in Wonolopo, Mijen, Semarang City, to analyze environmental conditions, electrical installations, and potential risks associated with power outages. Additional observations were carried out at the Data Communication Laboratory of Politeknik Negeri Semarang to study system integration requirements and evaluate the feasibility of IoT-based monitoring under controlled laboratory conditions. Discussions with farmers and field practitioners were also conducted to understand operational needs, such as maintaining ventilation, temperature, and lighting during power disturbances. The findings from this stage served as a foundation for determining the system's technical specifications, functional requirements, and design parameters to ensure that the proposed IoT-based solution could effectively address real challenges in poultry farm operations.

3.2 Planning

In the planning stage, the research team formulated the system requirements and selected appropriate hardware and software components based on the observation results. The hardware design included the PZEM-004T voltage sensor and ACS712 current sensor as detection units, a NodeMCU ESP8266 microcontroller as the central control unit, and a mini UPS module to ensure continuous operation during outages. The Blynk IoT platform was chosen for cloud-based data monitoring and mobile notifications. This stage also involved defining the data flow structure, Wi-Fi communication configuration, and criteria for system evaluation to ensure accuracy, responsiveness, and reliability in detecting power supply disruptions.

3.3 System Design

3.3.1 Tool System Design

The overall architecture of the proposed IoT-based power supply detection and warning system is illustrated in Figure 2. This architecture integrates both hardware and software components to enable intelligent monitoring, data communication, and real-time alerting functions. The system continuously measures voltage and current parameters using the PZEM-004T v3.0 sensor, which is directly interfaced with the ESP32 microcontroller through serial communication. Acting as the central processing unit, the ESP32 not only processes the acquired electrical data but also transmits it wirelessly to the Blynk cloud platform, enabling seamless synchronization with the user's smartphone application. When the system detects an abnormal condition, such as a significant voltage drop or a complete power outage, it automatically activates a relay module that triggers a sirene alarm to provide immediate on-site notification. Concurrently, the system sends an instant alert to the user's mobile device, ensuring rapid awareness and response. To maintain reliability during operation, all components are supported by a 12V external power supply, ensuring uninterrupted performance and stable connectivity even under fluctuating electrical conditions.

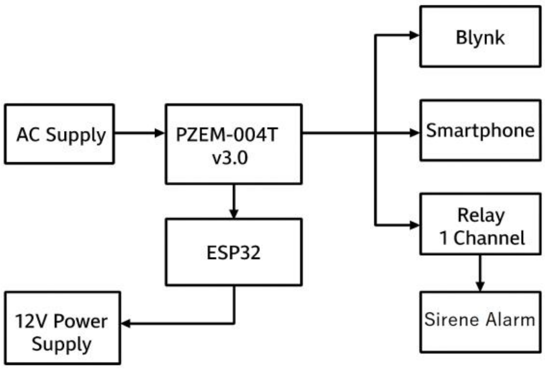

Fig 2. Block diagram of the IoT-based electricity supply detection and warning system

Figure 2 illustrates the block diagram of the IoT-based electricity supply detection and warning system. The system integrates both sensing and control components to ensure continuous monitoring of the power supply in poultry houses. The AC supply serves as the primary input source, which is measured by the PZEM-004T v3.0 sensor to determine real-time voltage and current levels. The sensor transmits the collected data to the ESP32 microcontroller, which functions as the central processing unit responsible for analyzing the electrical parameters and managing communication with the cloud platform.

Through a Wi-Fi connection, the ESP32 sends the processed data to the Blynk cloud platform, enabling users to access the system's status and receive real-time notifications via their smartphones. When a power outage or voltage drop is detected, the ESP32 activates the relay module, which in turn triggers the sirene alarm as an immediate local alert for farm operators. Additionally, a 12V external power supply ensures that the sirene and controller receive sufficient energy for stable operation, even under fluctuating power conditions. Overall, this configuration provides an efficient and reliable method for early detection of electrical disturbances, helping farmers maintain optimal environmental conditions in their poultry facilities.

To provide a clearer understanding of the interaction between hardware and software components, the complete configuration of the IoT-based electricity supply detection and warning system is presented in Figure 3. This configuration demonstrates how each module, from power input, sensing, and data processing to wireless communication and alert mechanisms, works together as an integrated system. The diagram also highlights the flow of electrical power and data communication pathways, illustrating the connection between the ESP32, sensor modules, relay, sirene alarm, and the Blynk mobile application.

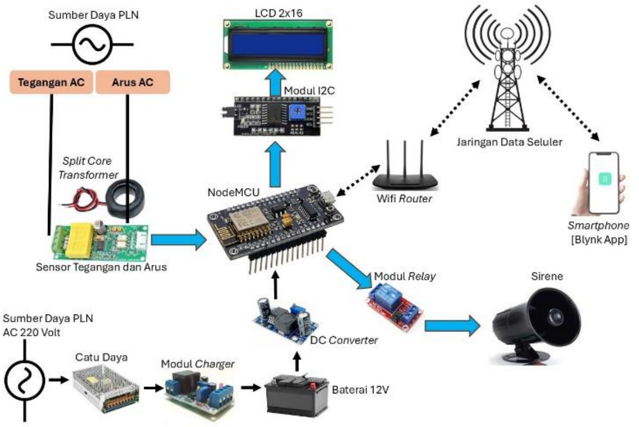

Fig 3. Configuration diagram of the IoT-based electricity supply detection and warning system

Figure 3 illustrates the overall configuration of the IoT-based electricity supply detection and warning system implemented in this study. The system is designed to continuously monitor the AC power supply from the main grid (PLN) and provide both local and remote alerts in the event of a power disturbance. The voltage and current from the AC source are first measured by the voltage and current sensor module, which includes a split-core current transformer for safe and accurate current measurement. The acquired data are transmitted to the microcontroller, which serves as the main control and communication unit of the system.

The microcontroller processes the sensor data and displays real-time readings through an LCD 2x16 module connected via an I2C interface, allowing users to observe power conditions directly on-site. Simultaneously, the microcontroller communicates wirelessly with the Blynk mobile application through a Wi-Fi router and cellular data network, enabling remote monitoring and instant notifications on the user's smartphone.

In the event of a detected power failure, the microcontroller activates a relay module, which triggers a sirene alarm as an immediate local warning. To ensure the system remains functional during power outages, a 12V battery and charging module are integrated, supported by a DC converter and power supply unit connected to the AC source. This backup configuration maintains power for the microcontroller and communication components, guaranteeing uninterrupted IoT connectivity and alarm functionality.

Overall, this configuration ensures a reliable, real-time, and responsive power monitoring system suitable for maintaining the operational safety of electricity-dependent poultry farms.

3.3.2 Mobile System Design

The mobile system design was developed using the Blynk IoT platform, which serves as a real-time monitoring and control interface for the poultry house electricity supply. The mobile application enables users to visualize electrical parameters directly from their smartphones, providing convenient access to system data and control functions regardless of location. Figure 4 shows the layout of the Blynk mobile dashboard designed for this study.

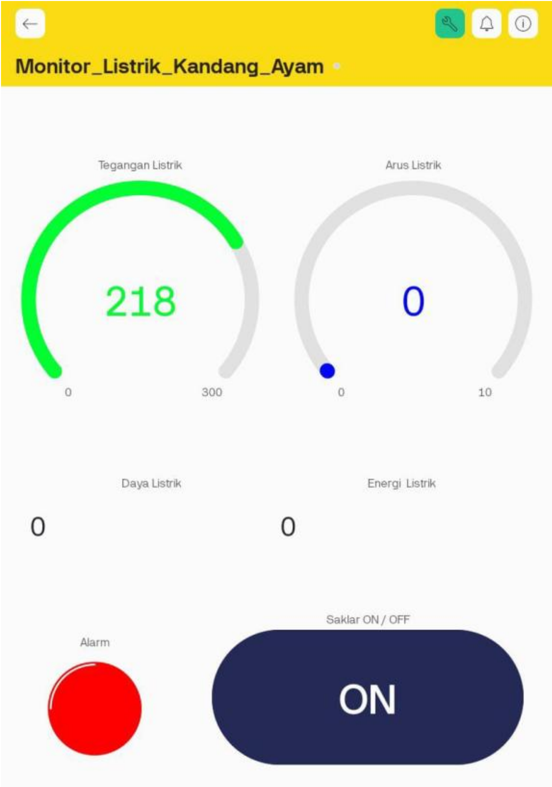

Fig 4. Display of the Blynk mobile dashboard

Figure 4 displays the main interface of the "Monitor_Listrik_Kandang_Ayam" system. The dashboard consists of multiple widgets that represent the system's monitoring and control features. The voltage gauge on the left shows the real-time voltage value in volts, while the current gauge on the right displays the corresponding current measurement in amperes. These two parameters are obtained from the PZEM-004T v3.0 sensor and transmitted via the NodeMCU microcontroller through a Wi-Fi connection.

Below the gauges, the dashboard also presents the calculated electrical power and energy consumption, which are automatically computed from the voltage and current readings. The Alarm indicator is shown as a red button that activates when an electrical disturbance or power outage is detected, providing a visual alert to the user. In addition, a switch control labeled "Saklar ON/OFF" allows users to manually control connected devices, such as the sirene alarm, directly through the mobile application.

This mobile design ensures that farmers can monitor the power status of the poultry house in real time, receive immediate notifications of power interruptions, and take rapid action when necessary. By integrating the Blynk platform, the system provides both automation and remote accessibility, enhancing the reliability and responsiveness of power management in poultry farming operations.

3.4 System Creation

The system creation stage involved integrating all hardware and software components into a functional prototype capable of detecting and responding to electrical disturbances in real time [13]. This stage combined the design, assembly, and programming processes based on the system architecture previously outlined and visualized in Figure 5.

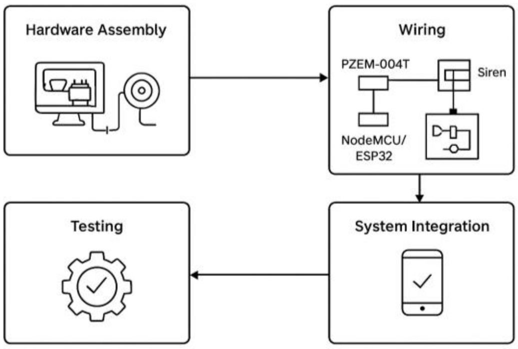

Fig 5. Process of developing the IoT-based power supply detection and warning system

As illustrated in Figure 5, the system creation process consisted of four main phases: hardware assembly, software programming, system calibration, and testing. On the hardware side, the voltage and current sensors (PZEM-004T v3.0) were connected to the microcontroller, which served as the central unit responsible for data acquisition and communication. The relay module and sirene were configured to operate as the warning mechanism, activating whenever a power failure or voltage drop was detected. The entire system was powered by a DC converter and supported by a 12V backup battery to maintain operation during outages.

For the software implementation, the microcontroller was programmed using the Arduino IDE with integrated libraries for Wi-Fi, Blynk, and sensor data processing. The firmware was developed to continuously read voltage and current values, process them, and transmit the information to the Blynk cloud platform. Through this connection, users can monitor power conditions and receive real-time alerts directly on their smartphones.

After the assembly and programming phases, the system underwent calibration and testing to ensure accurate sensor readings, reliable wireless communication, and fast response times for notifications and sirene activation. This integration of hardware and software components resulted in a responsive, stable, and user-friendly IoT-based power monitoring and warning system suitable for poultry farm environments.

3.5 Test Design

The testing stage was conducted to evaluate the performance, reliability, and accuracy of the IoT-based electricity supply detection and warning system developed in this study. The testing was designed to simulate real operational conditions in poultry houses and to verify that the system performs according to its intended functions. The tests focused on assessing three main aspects: **sensor accuracy, system response time, and notification reliability**.

Two main test scenarios were established to evaluate the system's performance under different operating conditions. In the normal condition, the power supply from the AC source (PLN) remained stable and within the expected voltage range of approximately 220 V. During this phase, the system was expected to continuously monitor and display voltage and current readings accurately without generating false alarms or notifications. In contrast, the disturbance condition involved intentional power outages and voltage fluctuations introduced to simulate real-world disruptions. This scenario was designed to test the system's ability to promptly detect abnormal electrical conditions, activate the sirene alarm, and send real-time notifications to the user via the Blynk mobile application.

During each scenario, several parameters were recorded, including voltage and current readings from the PZEM-004T v3.0 sensor, the detection time of power disturbances, and the duration between detection and notification delivery through the Blynk mobile application. The notification response time was measured to ensure the system could provide real-time alerts to users within an acceptable delay threshold of less than 3 seconds.

The testing setup was implemented both in the Data Communication Laboratory of Politeknik Negeri Semarang and in the closed poultry house at Wonolopo, Mijen, to compare indoor laboratory performance with real environmental conditions. All collected data were analyzed to determine the system's accuracy, stability, and reliability in providing early warnings of power supply disruptions.

The system enables real-time monitoring of environmental parameters and allows both automatic and manual control of devices through a mobile application, as shown in Figure 6.

Fig 6. Testing of the IoT-based monitoring and control system in the closed poultry house at Wonolopo, Mijen

To evaluate the system performance under different conditions, testing was performed in both field and laboratory environments. Figure 7 shows the laboratory testing conducted at Politeknik Negeri Semarang.

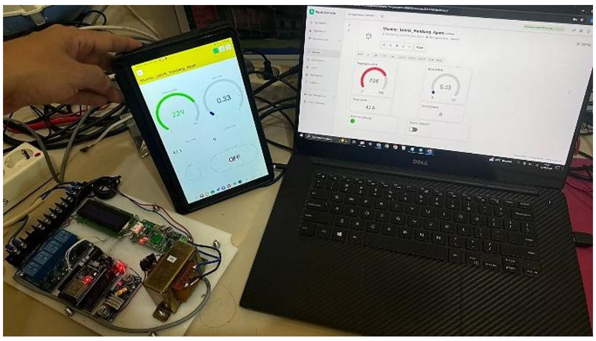

Fig 7. Testing of the IoT-based monitoring and control system in laboratory

4. Results and Discussion

4.1 Laboratory Testing Results

The initial testing was carried out at the Data Communication Laboratory, Politeknik Negeri Semarang, to ensure that the system functioned as designed. The objectives of this phase were to evaluate the sensor accuracy, system response time to changes in electrical conditions, and the real-time notification capability through the Internet.

The ZMPT101B voltage sensor and ACS712 current sensor were tested using a variable power source (autotransformer) with voltage variations ranging from 150 to 230 V. The measurements were compared with readings from a standard digital multimeter to calculate the system's accuracy level. Table 1 shows the results of the voltage sensor accuracy test.

Table 1. Voltage sensor accuracy test

No	Reference Voltage (V)	Measured Voltage (V)	Difference (V)	Accuracy (%)
1	150	152	2	98.7
2	180	179	1	99.4
3	200	198	2	99.0
4	220	217	3	98.6
5	230	226	4	98.3

The average measurement accuracy reached 98.8%, with a mean error of 1.9%. These results indicate that the ZMPT101B sensor is sufficiently reliable for detecting voltage fluctuations within the operational range of poultry farm electrical systems.

In addition, the system response time to power outages was tested. The response time was measured from the moment voltage dropped below 50 V until the notification was successfully sent to the Blynk application. Table 2 presents the response time results obtained from five simulated power outage tests.

Table 2. Response time results obtained

No	Test Condition	Detection Time (s)	Notification Time (s)	Total Response (s)
1	Outage 1	0.85	2.01	2.86
2	Outage 2	0.89	1.95	2.84
3	Outage 3	0.91	1.87	2.78
4	Outage 4	0.93	2.10	3.03
5	Outage 5	0.80	2.00	2.80

The system achieved an average total response time of 2.86 seconds, with minimal variation (<0.3 seconds). This demonstrates that the system can deliver early warnings in less than 3 seconds after detecting a power outage, giving farmers sufficient time to activate a backup generator.

4.2 Field Implementation Results

Field trials were conducted for seven consecutive days in a closed poultry house with a capacity of 12,000 chickens located in Wonolopo, Mijen, Semarang. This site was selected because its ventilation and heating systems rely entirely on electricity.

During the testing period, the system was evaluated under two main conditions:

1. Normal Condition, where the power supply remained stable, and the system performed continuous monitoring.
2. Disturbance Condition, where power outages and voltage drops (down to 170 V) were intentionally simulated.

The experimental results showed that the system:

- Successfully displayed real-time voltage and current data on the Blynk dashboard.
- Sent automatic notifications with an average delivery time of 2.9 seconds.
- Stored data logs in the Blynk cloud for historical analysis.
- Remained active for up to 32 minutes during power outages using a 12V/9Ah mini UPS.

Additionally, the partnered farmers reported that the system significantly improved their response time during power failures. Before implementation, the average time required to activate a generator ranged from 5 - 7 minutes. After deploying the system, the response time dropped to approximately 1 minute, as farmers received instant notifications on their smartphones.

4.3 System Performance Analysis

Based on the results obtained from both laboratory and field testing, the system's performance was evaluated using three main parameters: detection accuracy, response time, and endurance during power outages.

The system demonstrated a detection accuracy ranging from 97.6% to 99.0%, with an average response time between 2.8 and 3.0 seconds, and maintained continuous operation for approximately 30 minutes using a 12V/9Ah mini UPS during power interruptions.

This level of performance is categorized as excellent, meeting the ideal standards for farming IoT systems, which require rapid detection, real-time notifications, and uninterrupted functionality even in the event of power failures. In terms of energy efficiency, the microcontroller consumed approximately 0.3 watts, enabling the backup power system to sustain stable operation for more than half an hour during outages.

4.4 Discussion

The results demonstrate that the developed IoT-based power supply detection and warning system operates effectively and stably in both laboratory and real-world environments. The system successfully performs real-time power monitoring, automatic notification, and supports operational continuity in poultry farms through the use of backup power.

Beyond technical improvements, the system also provides socio-economic benefits. The early warning capability can reduce poultry mortality rates by up to 70%, while minimizing operational losses from equipment failure and decreased productivity.

However, several limitations were identified throughout the system's development and testing. The system still relies heavily on a stable Wi-Fi connection, which may affect real-time notifications in areas with poor network coverage. Additionally, it currently lacks a predictive fault detection mechanism that can analyze historical electrical data to anticipate potential failures before they occur. Another limitation is the restricted endurance of the mini UPS, which can only sustain operation for approximately 30 minutes and is therefore unsuitable for prolonged power outages exceeding one hour.

These limitations highlight important directions for future research, particularly the integration of artificial intelligence (AI) to enable predictive analysis and the adoption of solar power systems as alternative, sustainable energi sources to ensure long-term operational reliability.

4.5 Summary of Findings

In summary, the findings of this study demonstrate that the developed IoT-based power supply detection and warning system performs effectively and reliably in both laboratory and real-world environments. The system achieved a detection accuracy of 97.6 - 99.0%, with an average notification delivery time of 2.86 seconds through the Blynk mobile application. Additionally, it remained fully operational for approximately 30 minutes during power outages using a mini UPS as a backup source. Field implementation further showed that the system significantly enhanced the farmers' responsiveness, reducing the time required to activate backup generators by up to five times faster compared to previous manual practices. These outcomes underscore the potential of Internet of Things (IoT) technology as a practical and efficient digital solution to improve reliability, resilience, and operational efficiency in modern poultry farm power management systems.

5. Conclusion

Based on the results of the design, testing, and analysis of the IoT-based power supply detection and warning system for closed poultry houses, several conclusions can be drawn as follows:

1. The developed system successfully achieved the intended research objectives.
   The system was able to perform real-time power disturbance detection using the ZMPT101B voltage sensor and ACS712 current sensor, achieving an average measurement accuracy of 98.8%. This finding demonstrates that the combination of these sensors with the NodeMCU ESP8266 microcontroller can effectively monitor electrical conditions in dynamic poultry farm environments.
2. The system provided early warnings with a fast response time.
   Based on laboratory and field tests, the average time from disturbance detection to notification delivery via the Blynk application was 2.86 seconds. This response time is well below the 5-second threshold commonly accepted for rapid IoT-based warning systems, proving its effectiveness for real-time monitoring applications.

3. The system remained operational during power outages.
   Integration with a 12V/9Ah mini UPS allowed the system to remain active for approximately 30 minutes after a power failure, ensuring uninterrupted notification delivery. This confirms that the system meets both reliability and availability requirements during emergency conditions.
4. Field implementation improved response and operational efficiency.
   The implementation conducted in a closed poultry house in Wonolopo, Mijen, showed that farmers could respond to power outages five times faster than before system deployment. Consequently, this significantly reduced the risk of chicken mortality caused by power failures and minimized potential economic losses.
5. This research provides both technical and socio-economic contributions.
   From a technical perspective, the system integrates three essential elements—detection, real-time notification, and backup power integration, into a single, efficient IoT platform that is easy to implement. From a social perspective, the system offers a digital solution that helps poultry farmers maintain operational stability and improve livestock welfare through affordable smart technology.

Overall, the findings demonstrate that IoT technology has significant potential to enhance energy efficiency, operational safety, and system resilience in modern poultry farming operations that depend heavily on continuous electricity supply.

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