

## Design of a National-Standard Electrical Installation for a Polyclinic: A Case Study of Cibubur Hospital Polyclinic with Load, Lighting, and Backup System Analysis

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**Abstract:** Electrical installation systems in healthcare facilities must ensure safety, reliability, and operational continuity because medical services depend on stable power supply and adequate lighting conditions. In polyclinic environments, electrical disturbances may affect service quality and patient safety, making proper system design essential. **Objective:** This study aims to design and evaluate the electrical installation of the Cibubur Hospital Polyclinic based on national standards, focusing on load distribution, lighting performance, backup power systems, and grounding effectiveness. **Method:** This research employs a mixed qualitative–quantitative descriptive approach. Data were collected through field observations, direct measurements using electrical instruments (clamp meter, lux meter, and earth tester), and documentation review of installation layouts and technical standards. The analysis was conducted through technical calculations and standard-based evaluation. **Results:** The total electrical load is divided into 11,883 W for normal PLN load and 7,406 W for priority UPS load, indicating a functional separation between general and critical services. Lighting measurements show that seven out of ten rooms meet the required standards, while three rooms remain below the threshold. The grounding system demonstrates resistance values well below the allowable limit, indicating effective protection performance. **Implications:** The results indicate that integrated electrical installation design can support safe and continuous healthcare operations, although improvements in lighting uniformity and system specification consistency are still required. **Originality:** This study offers an integrated evaluation of load distribution, lighting, backup power, and grounding within a single polyclinic case study, providing practical and academic contributions to electrical system design in healthcare facilities.

**Keywords:** Electrical Installation; Polyclinic; Lighting System; UPS; Grounding System.

## INTRODUCTION

Healthcare facilities require electrical systems that are safe, stable, and reliable because almost all clinical services depend on continuous electricity supply. In a polyclinic, electrical energy supports examination lighting, medical devices, computers, communication systems, air-conditioning units, and various other service-supporting equipment (Kementerian Kesehatan Republik, 2016; Pemerintah, 2011). Electrical

disturbances such as overload, voltage drop, short circuit, or supply interruption may reduce service quality, interfere with diagnostic activities, and potentially threaten patient safety (Badan Standardisasi, 2001, 2011). Therefore, electrical installation planning in healthcare buildings must not only fulfill operational needs but also ensure safety, continuity, and technical reliability in accordance with applicable standards (Badan Standardisasi, 2011; Kementerian Kesehatan Republik, 2016).

In addition to supply continuity, lighting quality and backup readiness are also critical in healthcare environments. Adequate lighting supports visual comfort, examination accuracy, and staff work performance in clinical spaces, while insufficient illumination may increase visual fatigue and reduce the effectiveness of healthcare services (Dianat, 2013; Lo Verso, 2016). Reliable electricity has also been associated with better working conditions and higher service continuity in healthcare facilities, particularly in units that depend on uninterrupted operation of medical and supporting equipment (Chang, 2022; Hanada, 2007). From an engineering perspective, backup power systems and resilient electrical infrastructure are essential to maintain priority loads during disturbances or outages, especially in critical service environments such as hospitals and polyclinics (Balan, 2021; Salvaraji, 2022). Moreover, the growing concern for energy efficiency in hospital buildings has made integrated electrical planning increasingly important, not only for safety and reliability but also for sustainable resource management (Bagnasco, 2017; Psillaki, 2023). Previous studies may first be grouped into the category of electrical load planning and power demand analysis. In this category, researchers generally discuss connected-load estimation, installed-capacity calculation, and power requirement analysis as the basis for determining the adequacy of building electrical systems (Saifuddin et al., 2018; Cao et al., 2020).

Several studies also emphasize that accurate load planning is essential to avoid undersizing or oversizing electrical capacity, both of which may reduce operational efficiency and system reliability (Çetinbaş, 2019; Parise, 2020). In healthcare and other large buildings, load estimation is closely related to service continuity because electrical design must anticipate both normal operating loads and reserve requirements for critical functions (Cao, 2020; Parise, 2020). However, most studies in this group focus on general buildings or macro-level power adequacy and do not specifically address the integrated electrical needs of polyclinic services, where medical, lighting, and supporting loads must be coordinated in a more detailed manner.

Second, another body of literature focuses on electrical safety, protection systems, and grounding performance. Earlier work has shown that power quality disturbances, including voltage dips and electrical instability, can affect the performance of medical electrical devices and therefore become an important safety issue in healthcare facilities ([Hanada, 2007](#)). Other studies have discussed the importance of protection coordination, grounding design, and resilient electrical-system operation in hospitals, especially because these buildings contain sensitive equipment and critical service loads ([Balan, 2021](#); [Scarpino, 2017](#)). From the safety perspective, electrical protection is not only intended to prevent overload and short circuit, but also to maintain continuity of service and reduce risks for patients, staff, and medical equipment ([Salvaraji, 2022](#)). Even so, these studies are often limited to specific technical components, so protection analysis, grounding performance, and backup readiness are rarely evaluated together with lighting compliance and load distribution in one unified polyclinic case study.

Third, several studies have examined lighting systems and energy efficiency in healthcare buildings. Research has shown that illumination level, lamp distribution, and lighting quality influence visual comfort, occupational health, and work performance in hospital environments ([Dianat, 2013](#); [Leccese, 2016](#)). Other studies have highlighted that user satisfaction in healthcare spaces is also affected by the luminous environment, including lighting uniformity and perceived comfort ([Lo Verso, 2016](#)). In addition, the adoption of efficient lighting technologies has been discussed as an important strategy to improve the operational performance and energy management of medical facilities ([Hsieh, 2017](#); [Psillaki, 2023](#)). More recent evidence also confirms that lighting conditions in medical facilities remain an important issue from the occupational health perspective ([Demirarslan, 2024](#)). However, most of these studies discuss lighting performance as a separate issue and do not comprehensively integrate lighting compliance with load distribution, conductor and protection design, backup system adequacy, and grounding performance in a single polyclinic-based electrical installation study ([Bagnasco, 2017](#); [Sugianto, 2022](#)).

Based on these gaps, this study aims to design and evaluate the electrical installation of the Cibubur Hospital Polyclinic using an integrated standards-based approach. The study specifically analyzes load distribution, conductor and protection requirements, lighting adequacy, backup power capacity through UPS, and grounding performance. By combining field measurement and technical calculation in one healthcare case study, this

research is expected to provide a practical and academically relevant reference for the design of safe, efficient, and reliable electrical installations in polyclinic facilities.

This study argues that electrical installation planning based on an integrated analysis of load, protection, lighting, backup power, and grounding will better support the safety and operational continuity of polyclinic services. The working hypothesis is that a system designed according to technical standards and supported by appropriate load calculation, proper conductor and protection selection, adequate illuminance planning, sufficient backup reserve, and effective grounding performance will be more capable of meeting operational requirements and minimizing the risk of service disruption in healthcare facilities.

## RESEARCH METHOD

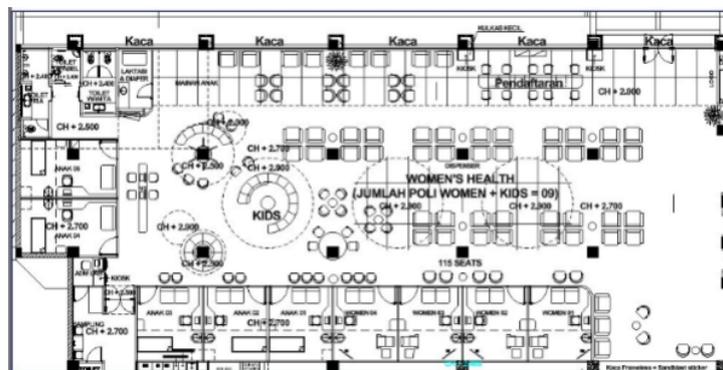
The unit of analysis in this study was the electrical installation system of the Cibubur Hospital Polyclinic, Jakarta, Indonesia. The study focused on the technical design and evaluation of the electrical system components that support healthcare services, including load distribution, lighting installation, socket outlets, conductors, protection devices, backup power supply, and grounding system performance. The polyclinic was selected as the object of study because it represents a healthcare service environment with continuous and safety-critical electrical demand, where system reliability, lighting adequacy, and protection performance are essential for operational continuity.

This study employed a mixed qualitative–quantitative descriptive design. The quantitative approach was used to calculate electrical load, conductor cross-sectional requirements, voltage drop, lighting needs, socket load, protection-device ratings, backup power capacity, and grounding resistance. The qualitative descriptive approach was used to interpret the suitability of the installation design with applicable technical standards and to describe the configuration of the electrical system in the polyclinic building. This design was chosen because the study did not merely measure technical variables, but also evaluated whether the installation planning and measured conditions were consistent with Indonesian electrical installation and healthcare facility standards.

The data used in this study consisted of primary and secondary data. Primary data were obtained directly from the Cibubur Hospital Polyclinic through field measurements and on-site technical observations conducted from January to April 2025. These data included room dimensions, electrical load data, installed lighting points, switch and socket

distribution, illuminance values, and grounding resistance values. Secondary data were obtained from relevant technical standards and regulatory documents, including PUIL 2011, SNI 6197:2011, SNI 03-6575-2001, IEC 60364, and the Regulation of the Minister of Health of the Republic of Indonesia Number 24 of 2016. Supporting references related to conductor capacity, protection systems, and lighting design were also used to strengthen the technical basis of the study.

Data collection was carried out through direct observation, field measurement, and documentation review. Observation was conducted to identify the layout of electrical components, such as lighting points, socket outlets, switches, and panel distribution, based on the basement general layout and installation plan drawings. Field measurements were performed using a clamp meter to identify load current, a lux meter to measure room illumination levels, and an earth tester to measure grounding resistance. In addition, room dimensions were measured and recorded to calculate the room index, lighting efficiency, and the required number of luminaires. Documentation review was conducted to examine technical drawings, equipment specifications, and applicable standards used as the basis for installation planning and evaluation.



**Figure 1.** Basement general layout of the Cibubur Hospital Polyclinic

The data were analyzed through technical calculation and standard-based evaluation. Electrical load data were analyzed by calculating total installed power, load grouping, and current requirements for lighting and socket circuits. Conductor sizing was analyzed based on current-carrying capacity and allowable voltage drop, while protection devices were evaluated based on calculated current and planned circuit characteristics. Lighting analysis was carried out using room index, utilization factor, depreciation factor, and illuminance standards to determine the required number of luminaires and the conformity of measured lux values. Backup power analysis was conducted by comparing UPS capacity with priority

load demand, while grounding analysis was performed by comparing measured earth resistance values with the maximum allowable standard. The final stage of analysis consisted of interpreting all calculation and measurement results to assess whether the electrical installation design met the technical requirements for safety, efficiency, reliability, and operational continuity in the polyclinic.

## RESULT

### Load Distribution and Electrical Power Requirement

The first result concerns the distribution of electrical load and the power requirement of the Cibubur Hospital Polyclinic. The analysis began with the identification of room zoning and the arrangement of electrical components in the service area. This step was important because the load calculation was not performed in isolation, but was based on the actual spatial distribution of luminaires, ceiling points, switches, and socket outlets in the polyclinic. To support this analysis, the composite ceiling arrangement, lighting layout, and socket outlet layout are presented in Figures 2–4.

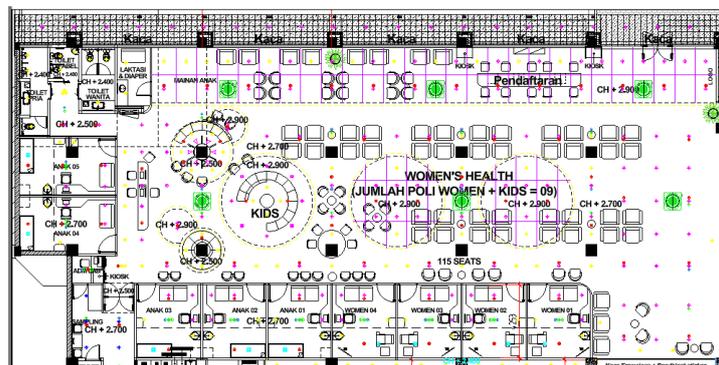


Fig. 2. Composite Ceiling Plan

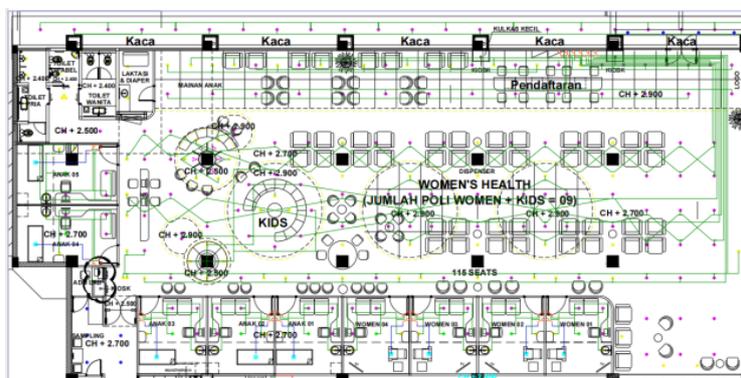


Fig. 3. Lighting Installation Plan



Based on Table 14, the total connected load supplied by the normal PLN source is 11,883 W, while Table 15 shows that the UPS-supported priority load is 7,406 W. In simpler terms, the electrical system is divided into two main categories: the general operating load supplied by PLN and the essential load supported by the backup system. Several patterns can be identified from these results. First, socket outlets contribute the largest portion of both PLN and UPS loads, indicating that the polyclinic relies strongly on electrically powered equipment. Second, the PLN load is considerably greater than the UPS load, which means that only selected circuits are prioritized during a power outage. Third, lighting contributes a smaller proportion of the total load compared with outlets, suggesting that service equipment is more dominant in the overall electrical demand. Fourth, the installation plans confirm that load grouping follows room function and operational priority.

These findings show that the electrical design already applies a functional separation between normal and critical loads. For a healthcare facility, such separation is essential because it allows important services to remain operational without requiring all building loads to be backed up simultaneously. Thus, the first result supports the research objective related to the evaluation of load distribution and electrical system planning in the polyclinic.

### Lighting Performance and Compliance with Illumination Standards

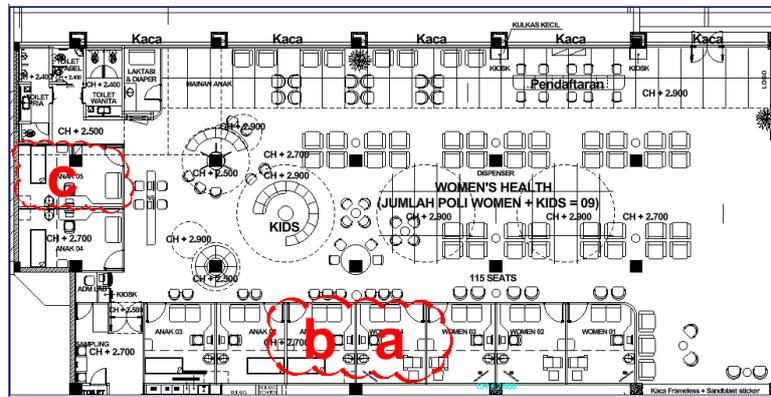
The second result concerns the adequacy of the lighting system in the clinical rooms and supporting spaces. After the load and installation layout were identified, field measurements were carried out to examine whether the actual illumination level in each room met the required standard. The measured data are presented in Table 16.

**Table 16.** Light Measurement

No.	Room	Standard Lux Value (SNI)	Measured Result (Lux)	Notes
1	Women's Clinic 1	250 Lux	250	Compliant
2	Women's Clinic 2	250 Lux	284	Compliant
3	Women's Clinic 3	250 Lux	322	Compliant
4	Women's Clinic 4	250 Lux	243	Not Compliant
5	Children's Clinic 1	250 Lux	233	Not Compliant
6	Children's Clinic 2	250 Lux	335	Compliant
7	Children's Clinic 3	250 Lux	303	Compliant
8	Children's Clinic 4	250 Lux	351	Compliant
9	Children's Clinic 5	250 Lux	234	Not Compliant

No.	Room	Standard Lux Value (SNI)	Measured Result (Lux)	Notes
10	Waiting Room	200 Lux	422	Compliant

To provide a clearer visual representation of the rooms that did not achieve the required lighting level, the non-compliant rooms are presented in Figure 5.



**Fig. 5.** Non-Compliant Illumination Rooms

Figure 5 visually highlights the spaces where the measured illuminance remained below the required standard. This image is important because it complements the numerical data in Table 16 by showing that the lighting issue is localized in specific clinical rooms rather than affecting the entire polyclinic area. The figure also strengthens the interpretation that the non-compliance is likely related to room-specific layout and luminaire distribution rather than to a total failure of the lighting system.

Based on Table 16, seven out of ten rooms comply with the required illumination standard, while three rooms remain below the minimum threshold. The compliant rooms are Women's Clinic 1, Women's Clinic 2, Women's Clinic 3, Children's Clinic 2, Children's Clinic 3, Children's Clinic 4, and the Waiting Room. The non-compliant rooms are Women's Clinic 4, Children's Clinic 1, and Children's Clinic 5.

Restated more simply, the lighting design performs adequately in most of the evaluated rooms, but several clinical rooms still require improvement. This means that the installation is generally functional, although the distribution of light is not yet fully uniform across all examination and service spaces.

Several patterns emerge from these results. First, most rooms already satisfy the standard, indicating that the general lighting strategy is broadly effective. Second, the three non-compliant rooms are only slightly below the standard, which suggests that the deficiency is moderate and may be corrected through design adjustment. Third, the waiting

room has the highest illuminance value at 422 lux, indicating stronger lighting performance in public circulation areas. Fourth, similar rooms do not always have similar lux values, implying that lamp placement and room geometry influence actual lighting outcomes.

These findings indicate that compliance with lighting standards must be validated through direct measurement, not merely assumed from the design stage. In this study, the results demonstrate that the lighting system is mostly adequate, but several rooms still need additional luminaires or better fixture arrangement. Therefore, the second result supports the research objective related to the evaluation of lighting performance and compliance with technical standards in the polyclinic.

### Backup Power and Grounding Performance

The third result concerns the readiness of the backup power system and the effectiveness of the grounding system as supporting elements of electrical safety and operational continuity. After analyzing the distribution of load and lighting performance, the study further examined whether the installation was supported by adequate protection-related infrastructure. In this context, the UPS-supported load had been identified previously in Table 15, while the grounding measurement results are presented in Table 17.

**Table 17.** Grounding Resistance Measurement Results

Grounding Location	Resistance Value (Ohm)	Panel Resistance Value (Ohm)	Maximum Limit (PULL)	Notes
Point 1	0.84	0.85	<5 Ohm	Compliant

Table 17 shows that the measured grounding resistance values are 0.84 Ω at the grounding point and 0.85 Ω at the panel. Both values are well below the maximum allowable limit of 5 Ω, indicating that the grounding system meets the required standard. In parallel, the UPS load shown earlier in Table 15 demonstrates that the backup system is allocated to priority loads such as examination lamps, selected lighting points, and UPS-designated outlets.

Restated more simply, the polyclinic electrical system is not only designed to distribute power, but also to maintain service continuity and protection. The UPS functions as a backup source for critical loads, while the grounding system provides a low-resistance path for fault current and supports safe operation of the installation.

Several tendencies can be observed from these data. First, the UPS-supported load is focused on essential functions rather than on the entire building load, indicating a selective backup strategy. Second, socket outlets make up the largest portion of the UPS-connected load, meaning that equipment continuity is a key priority. Third, the grounding resistance values are significantly below the allowable threshold, which reflects good earthing quality. Fourth, the coexistence of backup load allocation and compliant grounding performance suggests that the installation design considers both operational continuity and user safety.

These findings imply that the polyclinic electrical installation has incorporated the main technical requirements for reliability and protection. The UPS grouping shows that priority loads have been identified in advance, while the grounding results demonstrate compliance with the applicable resistance limit. Thus, the third result supports the research objective related to evaluating the readiness of backup power and grounding performance in ensuring safe and continuous healthcare services.

## DISCUSSION

The results of this study indicate that the electrical installation system of the Cibubur Hospital Polyclinic has been designed with a clear separation between normal load (PLN) and priority load (UPS), with total connected loads of 11,883 W and 7,406 W, respectively. The lighting system shows that seven out of ten rooms meet the required illumination standard, while three rooms remain slightly below the threshold. In addition, the grounding system demonstrates resistance values well below the maximum allowable limit, indicating compliance with safety standards. Overall, the findings show that the installation system is generally adequate, although several technical aspects still require improvement, particularly in lighting uniformity and consistency of backup system specification.

From a technical perspective, the observed results can be explained by the functional design approach used in the electrical installation. The dominance of socket outlet load over lighting load indicates that the polyclinic's electrical demand is largely driven by medical and electronic equipment rather than illumination. This explains why the UPS system is designed to prioritize socket outlets and selected lighting points, as these components are directly related to service continuity. The variation in lighting levels across rooms is likely influenced by differences in luminaire placement, room geometry, and utilization factors rather than by insufficient lamp capacity alone. Meanwhile, the low

grounding resistance values indicate that the earthing system has been properly installed, allowing effective fault current dissipation and ensuring electrical safety.

When compared with previous studies, the results of this study are consistent with findings that emphasize the importance of accurate load planning and prioritization in healthcare facilities (Cao, 2020; Parise, 2020). Similar to earlier work, this study confirms that electrical load in healthcare buildings is dominated by equipment usage rather than lighting. The findings also align with studies on electrical safety and grounding performance, which highlight that low resistance grounding is essential to maintain system stability and protect sensitive medical equipment (Balan, 2021; Hanada, 2007). In terms of lighting, the results support previous research indicating that lighting adequacy must be verified through field measurement, as design assumptions alone are not always sufficient to ensure compliance (Dianat, 2013; Leccese, 2016). However, the novelty of this study lies in its integrated evaluation approach, where load distribution, lighting performance, backup system readiness, and grounding effectiveness are analyzed together within a single polyclinic case study, rather than being treated separately as in many previous studies.

The findings of this study provide important implications for the understanding of electrical system design in healthcare facilities. The results show that compliance with technical standards is not only a matter of meeting design specifications but also requires verification through actual measurement and performance evaluation. The presence of non-uniform lighting levels, despite an overall adequate design, indicates that practical implementation may differ from theoretical planning. In addition, the clear separation between normal and priority loads highlights the importance of operational hierarchy in electrical system design, especially in environments where service continuity is critical. Thus, the study contributes to a more comprehensive understanding of how electrical installation design should integrate safety, reliability, and functionality.

From a reflective perspective, the results reveal both strengths and limitations of the current installation design. On the positive side, the system demonstrates good grounding performance, effective load grouping, and adequate support for critical loads through the UPS system. These aspects contribute to operational safety and service continuity. However, several limitations are also identified. The inconsistency in lighting performance across rooms indicates that the design has not fully achieved uniformity. In addition, the inconsistency found in the UPS capacity description within the manuscript suggests that design documentation and technical specification need to be more standardized and clearly

defined. These limitations highlight the importance of integrating design planning with verification and documentation processes.

Based on these findings, several practical implications and action plans can be proposed. First, lighting improvements should be carried out in rooms that do not meet the required standard, either by increasing the number of luminaires or optimizing their placement. Second, the UPS system specification should be clearly standardized and verified to ensure that the backup capacity is sufficient and accurately documented. Third, routine evaluation and measurement of electrical parameters, including lighting and grounding, should be implemented as part of maintenance procedures. Finally, future electrical installation design in healthcare facilities should adopt an integrated approach that simultaneously considers load distribution, lighting adequacy, protection systems, backup readiness, and grounding performance to ensure safe, reliable, and sustainable operation.

## CONCLUSION

This study demonstrates that the electrical installation design of the Cibubur Hospital Polyclinic has generally fulfilled the essential requirements of safety, reliability, and operational continuity. The results show that the electrical load is clearly divided into normal PLN load (11,883 W) and priority UPS load (7,406 W), reflecting a functional separation between general and critical services. The lighting system is mostly compliant, with seven out of ten rooms meeting the required illumination standards, although three rooms still require improvement. In addition, the grounding system shows resistance values well below the allowable limit, indicating effective protection performance. Overall, the main finding of this study is that an integrated approach to load distribution, lighting planning, backup power allocation, and grounding design can support safe and continuous operation in healthcare facilities.

The scientific contribution of this study lies in its integrated evaluation of electrical installation systems in a polyclinic context. Unlike previous studies that tend to examine load, lighting, or protection systems separately, this research combines multiple technical aspects—load distribution, lighting compliance, backup system readiness, and grounding performance—into a single analytical framework. This approach provides a more comprehensive understanding of how electrical installations in healthcare facilities should be designed and evaluated based on actual field conditions. In addition, this study

contributes practical insights for engineers and facility planners by demonstrating how standard-based design can be verified through measurement and performance evaluation.

However, this study also has several limitations. First, the analysis is based on a single case study, which limits the generalizability of the findings to other healthcare facilities with different scales or operational characteristics. Second, some inconsistencies in the documentation of UPS capacity and grounding values indicate that further verification and standardization of technical data are required. Third, the study focuses mainly on steady-state performance and does not analyze dynamic conditions such as transient disturbances, load fluctuations, or long-term system reliability. Therefore, future research is recommended to involve multiple case studies, more detailed electrical simulations, and deeper analysis of system performance under various operating conditions to provide a more comprehensive evaluation of electrical installations in healthcare environments.

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