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Technical Maintenance of Pole Mounted Circuit Breaker (PMCB) on the Tanjung Tembaga Feeder at PT PLN (Persero) ULP Probolinggo Distribution Network

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Abstract
The reliability of electrical distribution systems is critically dependent on the performance of protection devices such as the Pole Mounted Circuit Breaker (PMCB). This study focuses on the maintenance and performance evaluation of the PMCB installed on the Tanjung Tembaga feeder operated by PT PLN (Persero) ULP Probolinggo. The evaluation process involved a series of tests, including trip current and response time measurements, alongside supporting measurements on the Vacuum Circuit Breaker (VCB). The test results revealed that while trip current values slightly exceeded the standard of 15 A, they remained within acceptable technical limits. However, two out of three tests recorded trip times of 2 seconds, far above the standard maximum of 50 milliseconds, indicating a significant delay in fault response. In contrast, the VCB demonstrated optimal performance, with a contact resistance of 95 μΩ, an operational voltage of 110 VDC, and an insulation resistance of 1100 MΩ. These findings suggest that although the PMCB remains functionally capable of interrupting current, improvements are needed in its tripping mechanism to enhance response time. This study emphasizes the importance of routine testing and calibration to ensure the reliability and safety of medium-voltage distribution systems.

Keywords: Pole Mounted Circuit Breaker (PMCB), Vacuum Circuit Breaker (VCB), Electrical Distribution, Protection System, Reliability.

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1. Introduction

In the field of electrical power systems, the distribution system plays a vital role in ensuring the reliability and continuity of electricity supply to consumers [1].

One of the key components in medium-voltage distribution networks is the Pole Mounted Circuit Breaker (PMCB), a circuit breaker installed on utility poles that serves to protect the distribution network from faults such as short circuits and overloads [2]. PMCBs can be operated manually or automatically and form a critical part of the protection system designed to prevent wider damage to the distribution infrastructure during disturbances [3].

As electrical load demand and network complexity continue to increase, the reliability of protective equipment such as PMCBs becomes increasingly essential. Regular maintenance and performance testing, in accordance with technical standards, are required to ensure optimal functionality [4]. Without proper maintenance, PMCBs may fail to interrupt current flow during faults, potentially causing widespread outages and damage to other components in the system [5]. Therefore, comprehensive documentation and evaluation of PMCB maintenance processes are crucial to maintaining the performance of the distribution system [6].

This study was conducted at PT PLN (Persero) Unit Layanan Pelanggan (ULP) Probolinggo, specifically on the Tanjung Tembaga feeder, with the aim of examining the condition and maintenance procedures of PMCBs in the field [7]. The research provides a practical platform for applying electrical engineering knowledge and skills in real-world settings [8]. Activities carried out include field observation, technical data collection, and participation in maintenance processes such as physical inspections of PMCBs, trip system testing, and electrical measurements on supporting equipment like the Vacuum Circuit Breaker (VCB) [9].

Through this study, the author aims to gain a thorough understanding of the working principles of PMCBs and the systematic steps involved in their maintenance [10]. Additionally, this research seeks to contribute practical documentation of field conditions and performance evaluations of PMCBs, serving as a reference for enhancing the reliability of electrical distribution systems [11]. The findings of this study are also expected to provide insights for the development of protection systems in PLN's distribution networks and other utility organizations [12].

2. Methods

2.1 Methodology and Focus

The primary focus of this research is to evaluate the performance and reliability of Pole Mounted Circuit Breakers (PMCBs) by measuring key technical parameters, including trip current and response time, insulation resistance, main contact resistance, and operating voltage [13]. Data collection was conducted through direct field observation during PMCB maintenance and testing, along with documentation of measurement results using instruments such as a digital multimeter, insulation tester (megger), stopwatch, and standardized testing worksheets [14].

The collected data were compared against established technical standards, such as a nominal trip current of 15 Amperes and a maximum response time of 50 milliseconds. If any measured parameter exceeded these thresholds, it was deemed non-compliant and warranted further evaluation [15]. This approach provided an objective technical overview of PMCB condition and the effectiveness of the maintenance procedures [16]. The measurement results served as a foundation for performance analysis of the protection system and offered technical recommendations for equipment repair or replacement when necessary.

The PMCB maintenance and testing activities observed and executed in the field consisted of the following sequential steps:

1. **Preparation:** This step involved preparing the Permit to Work documentation, gathering necessary tools including a digital multimeter, insulation tester, and stopwatch, and ensuring scheduling and coordination with the technical team.
2. **Power Disconnection:** The electrical supply was safely isolated by opening the Fuse Cut Out (FCO) to create a secure working environment during maintenance.
3. **Physical and Functional Inspection:** Cleaning of PMCB components was conducted, along with lubrication and replacement of worn-out parts such as the battery and LCD display panel.
4. **PMCB Trip Testing:** Manual trip tests were performed three times to record the trip current (in amperes) and response time (in milliseconds). These results were then compared to the technical standard (nominal current of 15A and maximum response time of 50 ms).
5. **VCB (Vacuum Circuit Breaker) Measurements**: Supporting component measurements included main contact resistance (should be < 100 μΩ), insulation resistance (should exceed 1000 MΩ), and operational voltage (target value of 110 VDC), ensuring the auxiliary components were functioning properly.
6. **Data Analysis:** The collected measurement data were processed and analyzed to determine whether the PMCB operated according to technical specifications and electrical distribution safety standards.

This methodology allows for systematic evaluation of field-level PMCB performance and supports informed decision-making regarding asset reliability and maintenance planning in medium-voltage distribution networks.

3.Results and Discussion

The maintenance of PMCBs (Pole Mounted Circuit Breakers) is a critical preventive measure aimed at ensuring the reliability and safety of the electrical distribution network. The following steps outline the standard maintenance procedures undertaken in the field:

3.1 Maintenance Preparation

The initial step in performing PMCB (Pole Mounted Circuit Breaker) maintenance begins with the issuance of a Permit to Work (PTW) document. This document outlines the scheduled power outage and defines the scope of the maintenance activities to be undertaken. Following this, a detailed work plan is developed, listing specific tasks, required tools, and the timeline for execution. Equipment and material preparation includes essential instruments such as multimeters, lubricants, spare parts (e.g., springs, batteries, and LCD units), and cleaning supplies **Figure 1.**

Figure 1. Preparation for Maintenance Ceremony

3.2 Power Disconnection

The initial step in performing PMCB (Pole Mounted Circuit Breaker) maintenance begins with the issuance of a Permit to Work (PTW) document. This document outlines the scheduled power outage and defines the scope of the maintenance activities to be undertaken. Following this, a detailed work plan is developed, listing specific tasks, required tools, and the timeline for execution. Equipment and material preparation includes essential instruments such as multimeters, lubricants, spare parts (e.g., springs, batteries, and LCD units), and cleaning supplies **Figure 2.**

Figure 2. Power Disconnection Process

3.3 Visual Inspection

Once safety has been ensured, the next step involves a thorough visual inspection and cleaning of the PMCB components. The cleaning process includes removing accumulated dust and rust from electrical contacts and insulators using specialized cleaning agents that do not damage the component surfaces. This step is critical for maintaining electrical conductivity and preventing flashovers or arcing caused by surface contaminants or corrosion. In addition to surface cleaning, the mechanical components such as springs and levers are examined for signs of wear or physical damage that could impair the breaker's operation. Any worn or damaged parts must be replaced immediately to ensure that the PMCB maintains its protective function and can respond effectively to faults in the electrical distribution network **Figure 3.**

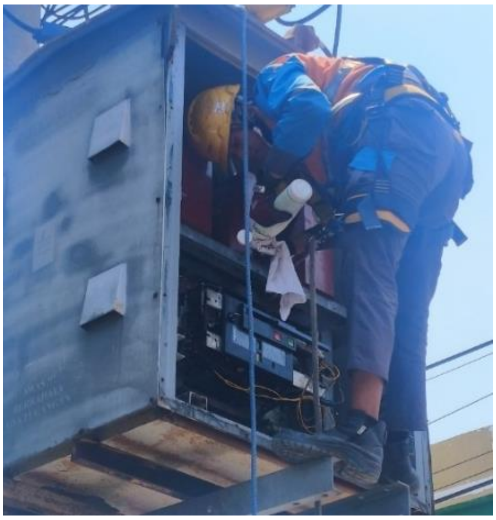

Figure 3. Dust and Rust Cleaning

3.4 Maintenance and Repair

The maintenance of the PMCB involves inspecting its supporting electronic components, particularly the battery and LCD display. The battery is evaluated to ensure its voltage remains within the acceptable range to adequately support the protection system's operations. If a drop in capacity or abnormal voltage is detected, immediate replacement is necessary to prevent failure in the trip mechanism. Furthermore, the LCD is visually examined to verify its proper functionality, including the clarity and visibility of the displayed data. If cracks, blackouts, or unreadable displays are observed, the LCD must be replaced to ensure that the PMCB’s operational status can be monitored accurately by technicians. This inspection of both components is crucial for maintaining the reliability of the PMCB’s control and monitoring systems, and to ensure prompt response in the event of electrical faults **Figure 4.**

Figure 4. Dust and Rust Removal

3.5 Testing

Based on the results of the PMCB (Pole Mounted Circuit Breaker) performance tests conducted three times, as shown in Table 1, the data reveal notable differences between standard values and actual outcomes in both trip current and trip time. In the first test, the trip current measured 15.01 A, slightly exceeding the standard value of 15 A, though still within acceptable tolerance. However, the recorded trip time was 2 seconds, which is significantly longer than the maximum standard of ≤ 50 milliseconds, thus failing to meet performance criteria.

The second test yielded similar results, with a trip current of 15.02 A—again marginally above the standard yet acceptable. However, the trip time remained at 2 seconds, again falling short of the technical requirements. In contrast, the third test reported a trip current of 15.05 A, slightly above the nominal but still acceptable, with a trip time of 50 milliseconds, which precisely meets the required performance threshold. Therefore, only the third test fully satisfies the protection criteria in terms of both current and timing parameters.

Table 1. PMCB Trip Test Results

Tes Ke-	Parameter	Standard Value	Test Result
1	Trip Current	15 A	15,01 A
	Trip Time	≤ 50 ms	2 seconds (delayed trip)
2	Trip Current	15 A	15,02 A
	Trip Time	≤ 50 ms	2 seconds (delayed trip)
3	Trip Current	15 A	15,05 A
	Trip Time	≤ 50 ms	50 milliseconds (compliant)

The next phase involved testing the Vacuum Circuit Breaker (VCB), as outlined in Table 2, to ensure that supporting components within the protection system operate optimally and continue to comply with established electrical standards. The measurements focused on three key parameters: main contact resistance, operational voltage, and insulation resistance. The measurement of main contact resistance is critical for verifying that electrical conductivity between terminals remains low enough to prevent overheating and voltage drops. Operational voltage testing ensures that the actuator circuit operates at its nominal voltage, in this case, 110 VDC. Lastly, insulation resistance was evaluated to assess the system's ability to prevent leakage currents, where the minimum acceptable value is set at 1000 MΩ. These test results serve as essential indicators for determining whether the VCB remains reliable or requires maintenance or replacement.

Table 2. VCB Measurement Results

No	Parameter	Standard Value	Measured Result
1	Main Contact Resistance	< 100 µΩ	95 µΩ
2	Operating Voltage	110 VDC	110 VDC
3	Insulation Resistance	> 1000 MΩ	1100

The measurements conducted on the Vacuum Circuit Breaker (VCB) focused on three critical parameters: main contact resistance, operating voltage, and insulation resistance. The standard value for main contact resistance is set at less than 100 µΩ to minimize power losses and heat generation during current flow. The measured resistance of 95 µΩ falls below the maximum threshold, indicating that the main contact remains in good operational condition.

For the operating voltage, the required standard is 110 VDC, and the measurement yielded exactly 110 VDC, confirming that the system receives the appropriate voltage to operate effectively. Regarding insulation resistance, the minimum acceptable value is greater than 1000 MΩ. The measured result of 1100 MΩ indicates excellent insulation quality, ensuring safety from potential current leakage. Overall, the measurements of all three parameters confirm that the VCB is in reliable working condition and capable of supporting the protection system's operational integrity.

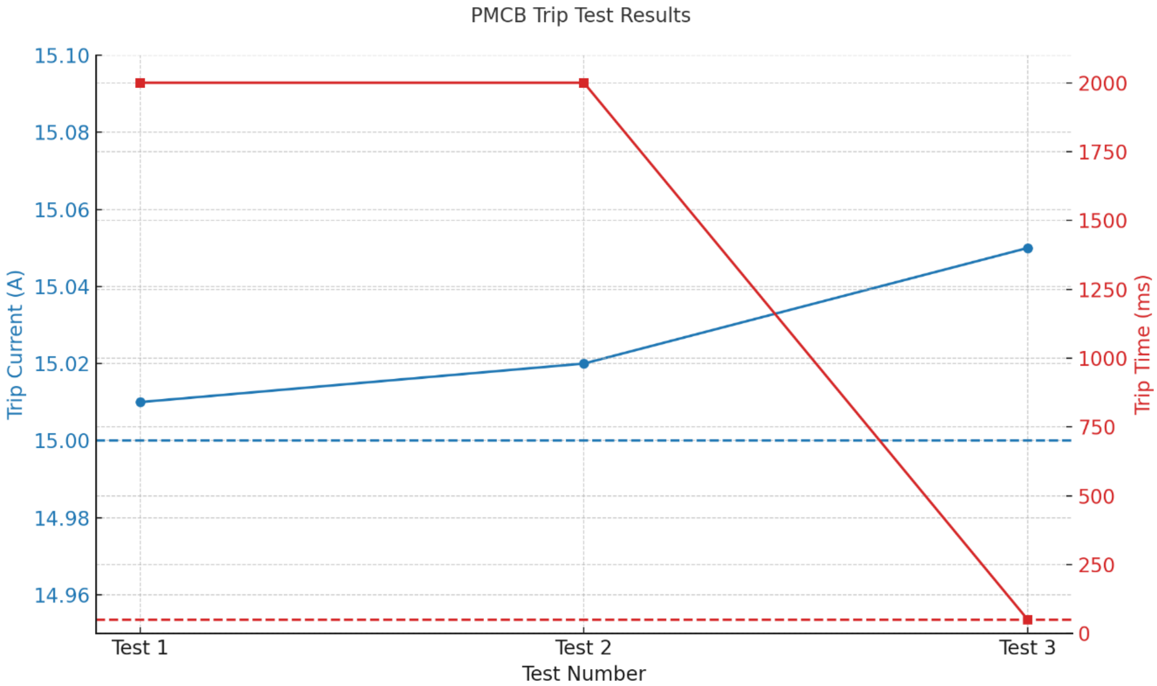

Figure 5. PMCB Trip Test Results

Based on the trip test graph for the PMCB (Pole Mounted Circuit Breaker), it is observed that the trip current values in all three tests are consistently slightly above the nominal standard of 15 A. Although these deviations exist, they remain within tolerable limits for the protection system, indicating that the PMCB is still performing with acceptable accuracy in terms of current interruption capability. However, a significant discrepancy is observed in the trip time results. In two out of the three tests, the PMCB recorded a trip time of 2000 milliseconds (2 seconds), which far exceeds the maximum response time standard of 50 milliseconds. This significant delay suggests a potential issue with the actuator mechanism or release system of the PMCB, which fails to respond quickly enough to ensure proper system protection.

While the third test showed compliance with the trip time standard, this inconsistency in performance raises concerns about the overall reliability of the PMCB. Both mechanical and control components of the system should be thoroughly evaluated. The graphical data imply that the PMCB's responsiveness to faults is not yet consistently stable, highlighting the necessity of regular maintenance and system calibration to ensure the continued optimal function of this protection equipment.

4. Conclusion

Based on the results of the study and testing conducted on the Pole Mounted Circuit Breaker (PMCB) located on the Tanjung Tembaga feeder, it can be concluded that, in terms of trip current measurement, all three tests produced values slightly above the standard threshold of 15 A, yet still within acceptable technical tolerance limits. However, the trip time results revealed a significant discrepancy in two out of the three tests, where the recorded trip time was 2 seconds—far exceeding the maximum allowable limit of 50 milliseconds. Only one of the tests met the expected response time criteria. These findings indicate that while the PMCB's current interruption capability is within acceptable parameters, the trip mechanism requires further evaluation and improvement. Meanwhile, the measurements taken from the Vacuum Circuit Breaker (VCB) demonstrated satisfactory performance in line with technical standards: a contact resistance of 95 μΩ, operational voltage of 110 VDC, and insulation resistance of 1100 MΩ. Therefore, the VCB is considered to be in operable condition. Overall, the findings suggest that while both devices remain functional, recalibration or mechanical adjustments to the PMCB's trip system are necessary to ensure faster and more reliable fault response within the electrical distribution network.

References

[1] N. Wang, Y. Wang, Y. Zhang, C. Tang, dan C. Sun, "An Operational Status Assessment Model for SF_6 High-Voltage Circuit Breakers Based on IAR-BTR," Sensors, vol. 25, no. 13, art. 3960, Jun. 2025. DOI: 10.3390/s25133960

[2] H. Zhao, "Mechanical Performance Degradation Modeling and Prognosis of Vacuum Circuit Breakers," Smart Materials and Structures, 2025. DOI: 10.1049/smt2.12235

[3] H. Chen et al., "Investigation on Fault Monitoring of High-Voltage Circuit Breaker Using Improved Deep Learning," PLoS ONE, vol. 18, no. 12, e0295278, 2023. DOI: 10.1371/journal.pone.0295278

[4] C.-C. Hsu, G. Frusque, M. Muratovic, C. M. Franck, dan O. Fink, "VCB Closing Time Key Moments Detection via Vibration Monitoring: A Run-to-Failure Study," arXiv preprint, 2022. DOI: 10.48550/arXiv.2208.07607

[5] M. Li et al., "Early Detection of Health Condition Degradation of Circuit Breaker Using Breakdown Current Ratio," Energies, vol. 16, art. 5581, 2023. DOI: 10.3390/en16145581

[6] H. Høidalen dan M. Runde, "Continuous Monitoring of Circuit Breakers Using Vibration Analysis," IEEE Trans. Power Deliv., vol. 20, no. 4, pp. 2458–2465, Oct. 2005. DOI: 10.1109/TPWRD.2005.854341

[7] E. Antur, D. M. Benenson, V. Demjanenko, dan S. E. Wright, "A Noninvasive Diagnostic Instrument for Power Circuit Breakers Using Short-Time Energy and Timing Techniques," IEEE Trans. Power Deliv., vol. 6, no. 4, pp. 1826–1834, 1991.

DOI: 10.1109/TPWRD.1991.255125

[8] N. Sampanis, "Innovative Tangible Interactive Games for Enhancing AI Knowledge in Elementary Education: A Pedagogical Framework," arXiv preprint, 2025. DOI: 10.48550/arXiv.2506.00651

[9] J E. D. Fylladitakis, "Fault Identification and Predictive Maintenance Techniques for High-Voltage Equipment: A Review and Recent Advances," Journal of Power and Energy Engineering, vol. 13, no. 7, pp. 1–39, Jul. 2025. DOI: 10.4236/jpee.2025.137001

[10] H. Chen, C. Han, Y. Zhang, Z. Ma, H. Zhang, and Z. Yuan, "Investigation on Fault Monitoring of High-Voltage Circuit Breaker Using Improved Deep Learning," PLoS ONE, vol. 18, no. 12, e0295278, 2023. DOI: 10.1371/journal.pone.0295278

[11] M. Li et al., "Early Detection of Health Condition Degradation of Circuit Breaker Using Breakdown Current Ratio," Energies, vol. 16, art. 5581, 2023. DOI: 10.3390/en16145581

[12] N. Wang et al., "An Operational Status Assessment Model for SF_6 High-Voltage Circuit Breakers Based on IAR-BTR," Sensors, vol. 25, no. 13, art. 3960, Jun. 2025. DOI: 10.3390/s25133960

[13] H. Zhao, "Mechanical Performance Degradation Modeling and Prognosis of Vacuum Circuit Breakers," Smart Materials and Structures, 2025. DOI: 10.1049/smt2.12235

[14] C.-C. Hsu, G. Frusque, M. Muratovic, C. M. Franck, and O. Fink, "VCB Closing Time Key Moments Detection via Vibration Monitoring: A Run-to-Failure Study," arXiv preprint, Aug. 2022. DOI: 10.48550/arXiv.2208.07607

[15] R. Natti and M. Kezunovic, "Model for Quantifying the Effect of Circuit Breaker Maintenance Based on Condition Monitoring Data," Texas A&M University Technical Report, 2023.

[16] Chandra D. Cahyo and S. Dhiya Ayuni, "Maintenance of Pole Mounted Circuit Breaker as Medium Voltage Network Protection at PT PLN (Persero) UP3 Sidoarjo," Procedia Engineering and Life Sciences, vol. 7, 2024.