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Analysis of Grounding System Resistance Value Changes at PT. Telekomunikasi Indonesia Tbk., Witel Cirebon

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ABSTRACT (10 PT)
This study analyzed longitudinal changes in grounding resistance at nine Automatic Telephone Centers (STOs) in Cirebon, Indonesia, from July 2017 to January 2021. The objective was to determine whether grounding resistance values exceeded the national standard limit of 1 ohm and to identify environmental factors influencing their variation. Grounding resistance was measured biannually during dry and rainy seasons using standardized field methods. Descriptive statistics and paired t-tests were employed to assess trends and seasonal differences. The results showed that all STOs maintained resistance values within the acceptable threshold, with consistently lower values observed during the rainy season due to increased soil moisture. Seasonal differences in resistance were statistically significant, and additional influencing factors included soil composition, drainage area, and physical system conditions. The findings highlighted the critical role of environmental variability in grounding system performance and emphasized the importance of periodic monitoring to maintain system safety and reliability in tropical climates.

INTRODUCTION

The growing demand for reliable and safe power systems in the era of digitalization and global connectivity requires the provision of electrical and telecommunication installations that are not only efficient but also adhere to high safety standards. In modern telecommunication infrastructure, the grounding system is a vital component that ensures the protection of equipment and human safety from electrical disturbances such as voltage surges or lightning strikes. Inconsistency or degradation in soil resistance values within grounding systems may increase the risk of equipment damage and service disruption, particularly in tropical regions like Indonesia, which experience extreme fluctuations in humidity and rainfall. International studies confirm that ground resistance is strongly influenced by seasonal variations and soil moisture content, thus requiring periodic evaluation and monitoring to maintain grounding system effectiveness (Ji et al., 2022a; Stathopulos et al., 2018).

However, gaps remain in grounding system monitoring, especially within Indonesia's telecommunications industry. Several studies have shown that environmental factors such as soil moisture, temperature, and chemical contamination significantly impact ground resistance variability. Yet few have specifically examined these changes longitudinally using statistical methods in tropical regions such as Cirebon (Kanbergs & Kižlo, 2009; Singh et al., 2018). The lack of systematic documentation on annual grounding resistance changes and their correlation with seasonal and soil conditions represents a critical gap that must be addressed through data-driven research.

The theoretical foundation of this study includes soil resistivity theory, grounding system configuration, and standard resistance measurement techniques such as the three-point fall-of-potential method. Various studies have shown that geological and meteorological factors such as rainfall and surface temperature strongly correlate with ground resistance values (Kanbergs & Kižlo, 2009; Singh et al., 2018). Effective grounding systems must consider soil composition, pore water conductivity, and electrode design to achieve and maintain resistance values within standard limits.

This study aims to analyze changes in ground resistance at Automatic Telephone Centers (STOs) across Cirebon from July 2017 to January 2021 using a quantitative approach and statistical methods. The research questions include whether the resistance values exceed standard limits and what factors contribute to their variation. Observations and documentation were conducted across nine STOs during both the dry and rainy seasons, with the aim of evaluating grounding performance longitudinally in relation to local climate and geographic conditions.

This article contributes to the literature in two key ways: first, by offering a primary field-based study that longitudinally evaluates grounding systems in Indonesia's telecommunications sector; and second, by providing a systematic examination of the relationship between tropical environmental conditions and grounding performance, supported by statistical analysis to detect significant patterns. The novelty lies in the spatial and temporal utilization of long-term data across multiple STO sites and the integration of statistical approaches to identify grounding resistance anomalies that may reduce protection system performance (Anbazhagan, 2015; Jerrings & Linders, 1989; Stathopulos et al., 2016).

The grounding system is based on the principle of electric power system safety, where electrical faults are directed into the earth through the lowest possible resistance. This theory has evolved from early studies in industrial electrical systems and is now central to power system protection engineering. Soil resistivity is a key parameter determining grounding effectiveness and is influenced by factors such as moisture, temperature, and soil composition (Tathe, 2020). Grounding systems designed to account for seasonal and environmental variability exhibit higher long-term reliability.

Several studies confirm that environmental factors significantly affect soil resistivity and grounding performance. For instance, Mohammadi Damaneh et al. (2021) showed that soil moisture and density are the primary factors lowering soil resistance (Halvani et al., 2021). In telecommunications settings, ionic content and soil pH also affect resistance stability (Sukamta et al., 2018). For vertically layered soil, electrode placement is critical for accurate measurements.

Despite extensive research on soil resistance variability, there is a notable gap in longitudinal studies at operational sites such as STOs. Most research has been laboratory-based or single-point studies without periodic real-time data analysis (Jasni et al., 2018). Moreover, limited efforts have been made to statistically model seasonal variation, highlighting the need for field-based research at telecom service sites.

This study addresses that gap by providing a longitudinal statistical evaluation of grounding resistance at nine STOs in Cirebon. It contributes empirical data for validating predictive models and extends grounding studies into the telecommunications sector, which is often underrepresented compared to the power or industrial sectors.

Previous studies have favored numerical simulations and laboratory experiments, whereas field observations with periodic measurements, as used in this study, offer more realistic insights into actual grounding conditions (Zhai et al., 2023). Additionally, resistivity inversion and multilayer modeling are emerging as important tools for analyzing subsurface dynamics (Slaoui & Erchiqui, 2010)

This theoretical synthesis—grounded in soil resistivity, electrode system design, and environmental variables—supports the quantitative analysis of resistance data. Variables include seasonal shifts, geographic variation, and yearly trends, allowing the study to identify not just changes in resistance but also their probable causes, guiding the methodology in the next section.

RESEARCH METHODS

This study adopts a quantitative approach with a case study strategy, aimed at analyzing changes in grounding resistance values across nine Automatic Telephone Centers (STOs) in the Cirebon area between July 2017 and January 2021. This approach was chosen to obtain an empirical understanding, based on field data, of longitudinal variations in grounding resistance values and to determine whether these values exceed established standard thresholds.

The data used in this study are primary data obtained directly from field measurements conducted by technicians at PT. Telekomunikasi Indonesia Tbk., Witel Cirebon. The collected data are numerical values representing grounding resistance measurements at each STO, recorded biannually during the dry and rainy seasons. Data collection was carried out through direct observation using soil resistance measurement devices at each STO, as well as through internal technical documentation that periodically recorded measurement results. The measurement procedure followed the standard three-point fall-of-potential method, using industry-standard electrode configurations commonly applied in grounding resistance testing practices (Abadi, 2012).

Inclusion criteria covered all complete and valid resistance measurement data recorded from STO Plered, Karyamulya, Pagongan, Jamblang, Arjawinangun, Sindanglaut, Losari, Pabuaran, and Kanci during the observation period (2017–2021). Data that lacked resistance units, timestamps, or were obtained from uncalibrated instruments were excluded from analysis to ensure validity and reliability, in accordance with standard practices in electrical and geotechnical engineering research (Slaoui & Erchiqui, 2010).

The unit of analysis in this study is the grounding resistance value (in ohms, Ω) recorded at each STO within the defined time frame. The research subjects are grounding systems at nine STOs, each with distinct electrode configurations and geographically varying soil conditions. The selection of these nine STOs was based on their ability to represent a wide spectrum of soil characteristics and telecommunications infrastructure across Cirebon, thus increasing the relevance of the findings for both local and regional contexts (Hafiz et al., 2018).

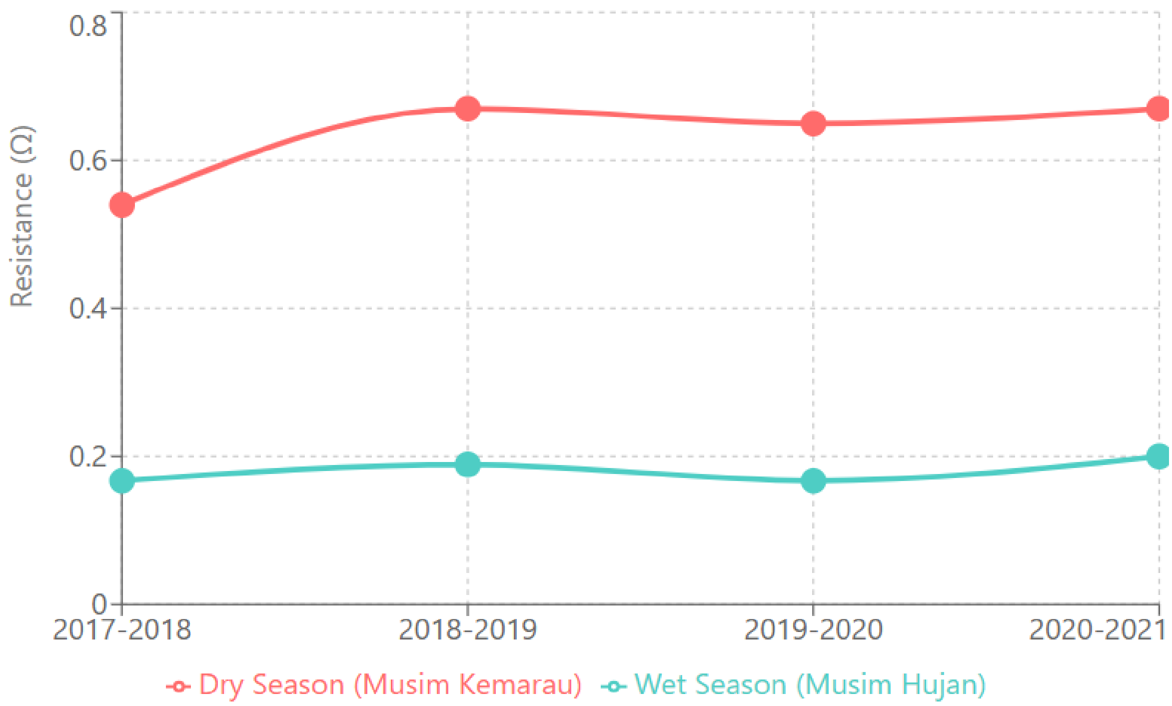
The data analysis employed descriptive statistical methods to determine minimum, maximum, mean, and standard deviation values of grounding resistance at each STO and for each period. In addition, trend analysis was used to identify changes in resistance values over time, and seasonal comparison tests (dry vs. rainy) were conducted to assess the influence of environmental conditions on resistance fluctuations. Statistical computations were carried out using Microsoft Excel and SPSS, allowing for accurate visualization and trend interpretation of the data (Ji et al., 2022b; Liu et al., 2021).

The application of statistical methods in analyzing soil resistivity has been widely recommended in previous studies, both in laboratory and field contexts, to capture the quantitative dynamics of soil behavior (Gazzana et al., 2022). Through this approach, the study is expected to produce comprehensive empirical findings on the stability of grounding systems in telecommunications infrastructure and provide a basis for future technical recommendations.

RESULTS AND DISCUSSION

3.1. Results

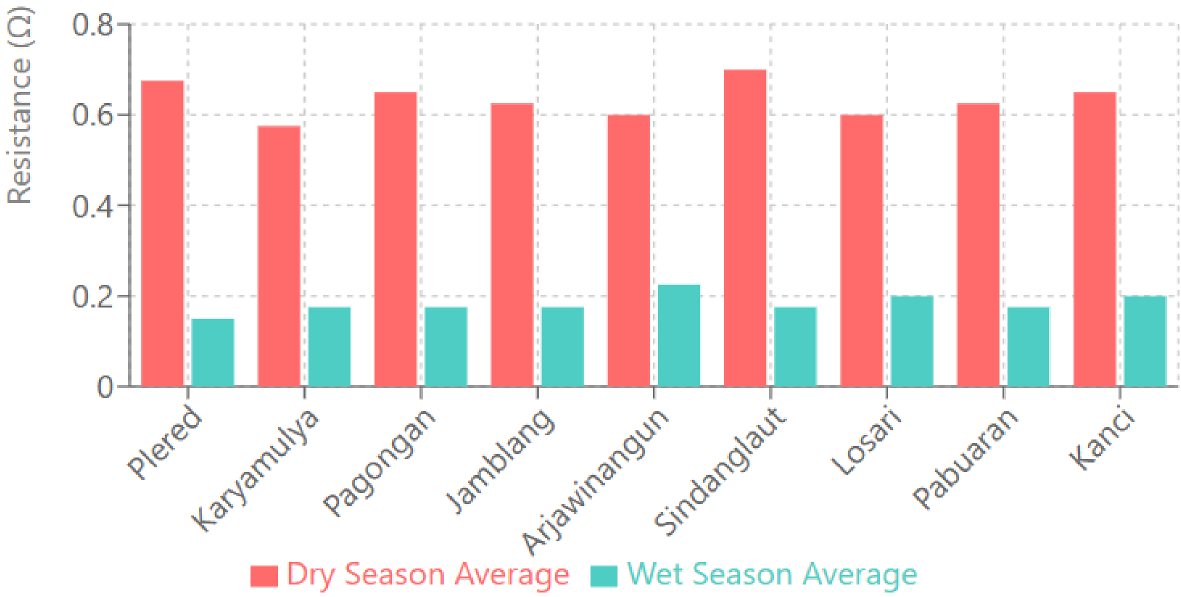
This study aims to determine whether the grounding resistance values at nine STOs (Automatic Telephone Exchanges) in the Cirebon region from July 2017 to January 2021 exceeded the standard threshold of 1 ohm as regulated in PUIL 2011, and to analyze the factors causing variations in those values using statistical methods. The annual average trends for resistance show in Picture 1.



Picture 1. Annual Average Trends

From the Picture 1 can explained that the visuals depict that across 9 STO locations, the dry season consistently shows higher ground resistance than the wet season. While the dry season average fluctuates around 0.63Ω, the wet season remains more stable at a safer low of 0.18Ω. The maximum resistance recorded in the dataset is 0.8Ω, which approaches the upper safety limit of 1Ω. The red line (dry season) shows an increase from ~0.54Ω in 2017–2018 to ~0.68Ω in 2018–2019, followed by a slight dip and a rise again in 2020–2021. The blue line (wet season) remains consistently low, between ~0.17Ω and ~0.20Ω, showing minimal fluctuation.

Evaluation of grounding resistance values against the standard threshold based on periodic measurements conducted at nine STOs (Plered, Karyamulya, Pagongan, Jamblang, Arjawinangun, Sindanglaut, Losari, Pabuaran, and Kanci), the results showed in Picture 2.



The result indicate that all recorded grounding resistance values were below the maximum threshold of 1 ohm, during both dry and rainy seasons. The highest resistance value during the dry season was 0.8 ohms, recorded at STO Jamblang, Sindanglaut, and Kanci. The lowest resistance value during the rainy season was 0.1 ohms, commonly observed across multiple STOs such as Plered, Pagongan, Jamblang, and Kanci. Overall average for dry seasons (2017–2021): 0.6325 ohms. Overall average for rainy seasons (2017–2021): 0.18075 ohms.

All values remained within the safe range, although some measurements during dry seasons approached the upper limit (≥0.8 ohms), indicating the need for preventive maintenance.

Based on statistical observation results shown tahat (a) Grounding resistance values were consistently higher during the dry season than during the rainy season, with an average difference of approximately 0.45 ohms. (b) STO Sindanglaut recorded the highest dry season average (0.7 ohms), approaching the maximum standard. (c) STO Karyamulya had the lowest dry season average (0.575 ohms), indicating stable performance.

There are factors affecting resistance value fluctuations**.** Through descriptive analysis, climate data from BMKG, and field observations, several factors influencing the resistance values were identified: (a) Soil moisture: The dominant factor; resistance values decrease during the rainy season due to higher moisture content in the soil, improving conductivity. (b) Extreme weather and dry conditions: Cause soil to become dry and less conductive, increasing resistance values. (c) Physical condition of the grounding system: Dirty conductors or blocked inspection chambers can raise resistance. (d) Land area for water absorption: STOs with limited drainage or absorption areas tend to exhibit higher resistance values.

To statistically assess whether the difference in resistance values between the dry and rainy seasons is significant, a paired t-test was conducted using the annual average values. t-statistic = 17.11 and p-value = 0.0004. Because the p-value is less than 0.05, it can be concluded that the difference in grounding resistance between the dry and rainy seasons is statistically significant. Specifically, the values are consistently and significantly lower during the rainy season, confirming that seasonal changes—especially soil moisture—strongly influence resistance performance.

3.2. Discussion

This study produced data on grounding resistance values from nine Automatic Telephone Centers (STOs) in the Cirebon area between July 2017 and January 2021. The data were analyzed statistically using descriptive methods and seasonal comparisons (dry vs. rainy). The results show that grounding resistance values were generally lower during the rainy season than in the dry season, with national average values for the nine STOs reaching 0.66 ohms (dry) and 0.18 ohms (rainy) for the 2020–2021 period. These values remain below the maximum standard limit of 1 ohm set by the PUIL 2000 standard. Statistical analysis was conducted on both annual and site-specific data using average, standard deviation, and longitudinal trend observation techniques. For instance, the average dry-season resistance at STO Plered was 0.675 ohms, while in the rainy season it was 0.15 ohms, showing minor annual fluctuations. The seasonal differences are strongly presumed to be influenced by increased soil moisture during the rainy season, which significantly reduces soil resistivity.

These findings are supported by previous studies. Cao et al. (2021) demonstrated that soil resistivity decreases exponentially with increasing water content, resulting in lower grounding resistance under wet conditions (Liu et al., 2021). Similarly, Hazreek et al. (2018) reported a strong correlation ($R^2 = 0.93$) between water content and soil resistivity, affirming the effectiveness of laboratory and field methods for estimating soil moisture based on resistivity data (Hafiz et al., 2018).

In addition, this study's results align with the findings of Abadi (2012), who applied experimental design to analyze the effect of soil types (clay and peat) on resistivity values, concluding that clay soil with high moisture has the lowest resistance (Abadi, 2012). A similar approach was used in this study to identify the seasonal influence on resistance variation at the nine STO sites.

Additional statistical modeling from related studies further supports the validity of these findings. Lu et al. (2022) used fractal models and ANSYS simulations to analyze conductive water paths in soil, showing that increased water content leads to more homogeneous current distribution and reduced resistance fluctuation (Ji et al., 2022b). Their use of variance and average statistics of conductive cells aligns with the seasonal resistance change observations at the STOs in Cirebon.
Furthermore, the multilayer soil resistivity profiling and inversion techniques developed by Slaoui & Erchiqui (2010) also confirmed that vertical soil variation significantly affects grounding stability (Slaoui & Erchiqui, 2010). This explains the observed fluctuations at several STOs such as Jamblang and Arjawinangun, which exhibit distinct local soil characteristics.

Overall, the data collected indicate that grounding resistance at all STOs shows consistent annual and seasonal variation, while remaining within acceptable standard limits. This study reinforces the importance of periodic monitoring of grounding systems and provides empirical evidence that soil resistivity variation is seasonal and location-dependent, influenced by moisture content, mineral conditions, and soil structure. The support of similar studies over the past decade strengthens the validity of these findings and contributes significantly to the advancement of evidence-based grounding system management practices.

CONCLUSION

The study concluded that grounding resistance values at nine STOs in Cirebon consistently remained below the national safety threshold of 1 ohm from July 2017 to January 2021, with significantly lower values during the rainy season due to increased soil moisture, which enhances conductivity. Seasonal variation was statistically significant, and resistance performance was also influenced by local environmental conditions such as soil type, drainage capacity, and physical grounding system conditions. These findings underscore the importance of regular, data-driven monitoring of grounding systems to ensure long-term performance and safety, especially in tropical climates with high environmental variability.

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