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Research Article

Analysis of Abnormal Hotspot Repair on the 500kV South Bandung – Mandirancan Transmission Line T.168 Using the Ohmstick Plus Live-Line Maintenance Method

Dendy Dwi Wardana[1]; Dendy Hizriyanto[1]; Muhammad Nur Azikin Akib[1*]
[1]PLN UIT JBT UPT Bandung Jl. PLN Cigereleng, Ciseureuh, Kec. Regol, Kota Bandung, Jawa Barat 40255
Corresponding author:** ***Muhammad Nur Azikin Akib, muhammad.nurazikin@pln.co.id

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Abstract: *The transmission system has the role of connecting generation centers with population growth centers. In the operation of the transmission system, it is not free from various disturbances and anomalies that can damage the reliability of the electricity distribution system. Hotspots are temperature abnormalities that occur in equipment that is powered by electric current, generally occurring at the connection point. Hotspots can cause losses because electrical energy is converted into heat energy at the point where the hotspot occurs. Hotspots can also cause equipment damage because they melt due to heat. Repair of hotspots that occur in conductor jumper clamps & link adjusters on SUTET 500KV South Bandung – Mandirancan (BDSLN-MDCAN) T.168 ARAH 167 FASA R. In this case it can be seen that a hotspot has occurred at an abnormal point. The point in question is the link adjuster, where this component functions to connect the yoke with the conductor to obtain the desired saging. The normal condition of the link is that there is no current so hotspots will not appear. OhmStick Plus is an instrumentation tool for measuring current and resistance in a connection directly and at voltage. So it will help describe the sequence of work points and serve to justify normal conditions after repair of the hotspot. The advantage gained when repairing hotspots using the PDKB method is that there is no need to wait for a scheduled power outage, especially when the anomaly status falls into the emergency category.*

Keywords: *Hotspot, OhmStick Plus, PDKB*

1. Introduction

The electrical system is a highly complex system consisting of three major components: the generation system, the transmission system, and the distribution system. The transmission system plays a crucial role in electricity delivery, often referred to as the lifeline of the power system, as it significantly influences the security and economy of a nation [1]. With the growing population, the demand for electrical energy also increases. This trend is evident in Indonesia, where population growth is on the rise. This presents a significant challenge for electricity providers in Indonesia, particularly in the transmission system, as power generation centers are often located far from population growth centers. However, the operation of the transmission system is not immune to various disturbances and anomalies that can compromise the reliability of electricity delivery.

A hotspot anomaly refers to an abnormal temperature rise in equipment carrying electrical current, typically occurring at connection points [2]. Several factors can cause these disturbances and anomalies, resulting in energy losses or interruptions in electricity delivery. Hotspot anomalies are among the most frequent issues, causing energy losses as electrical energy is converted into heat at the hotspot location. Additionally, hotspots can damage transmission equipment components due to high heat levels that cause melting.

Hotspot anomalies must be addressed promptly, as they can lead to energy losses, mechanical failures, and electrical failures. Transmission systems often experience hotspot anomalies due to high current loads. These anomalies can occur in High Voltage Transmission Lines (SUTT/SUTET) or substation installations (GI/GITET). Hotspots can be detected using thermovision devices, which measure temperature anomalies at hotspot locations. Periodic inspections using thermovision aim to detect the emergence of hotspots. Once a hotspot anomaly is detected, repairs are conducted by cleaning the hotspot area or adding jumper conductors. Hotspot repairs can be performed using two methods: with power outages or without power outages.

PLN's transmission network is a sensitive asset that significantly contributes to the company's success. Therefore, proper asset management in accordance with asset management standards is essential. Periodic inspections using thermovision and non-outage hotspot anomaly repairs are part of this effort. Based on these issues, the author has chosen to discuss the analysis of hotspot anomaly repairs on conductor jumper clamps and link adjusters in the 500kV SUTET BDSLN-MDCAN T.168 direction 167 R phase. In this case, it was found that a hotspot anomaly occurred at an abnormal point.

The objectives of this article are as follows:

- To identify recommendations for thermovision follow-up actions.
- To understand how to repair hotspot anomalies at abnormal points using the live maintenance method (PDKB) with the Ohm Stick Plus measuring tool.
- To analyze hotspot repairs using the Ohm Stick Plus instrumentation.
- To understand the effects of hotspot anomalies if their status escalates to a fault in the conductor.

2. Materials and methods

2.1. Location

Figure 1. Figure lable. T.168 SUTET 500KV BDSLN-MDCAN

Figure 1 shows Tower 168 of the 500kV SUTET BDSLN-MDCAN. The specifications of Tower 168 are as follows:

- **Tower Type**: Tension
- **Number of Circuits**: 1
- **Voltage**: 500 kV

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- **Phase Line Sequence**: BDSLN-MDCAN Left Phase: R,Middle Phase: S, Right Phase: T
- **Tower Location**: Darmawangi, Tomo District, Sumedang Regency, West Java
- **Geographical Setting**: Plantation
- **Conductor Cable**: ACSR HAWK 4 x 240/40 mm
- **Line Length**: 133.35 km

2.2. Thermovision Inspection Implementation

To detect hotspot anomalies, regular maintenance is required, specifically Level 1 inspections, which involve thermovision measurements on the BDSLN-MDCAN network from Tower 1 to Tower 186. These measurements are conducted once every six months, or once per semester. For thermovision measurements on the 500 kV SUTET BDSLN-MDCAN towers, a thermovision device from the Flir System brand is used. The thermovision measurement for the tower was carried out on **July 26, 2023**. The results of the inspection revealed that Tower 168 of the 500 kV SUTET BDSLN-MDCAN, particularly on Phase R, exhibited a hotspot anomaly on the conductor jumper clamp and link adjuster.

Figure 2. Illustration of Thermovision Inspection

During the thermovision inspection, the operator identified anomalies on the conductor jumper clamp and link adjuster of Phase R at Tower 168, directed toward Tower 167, specifically on the lower outer and inner strings. Figure 3 presents the thermovision inspection results for:

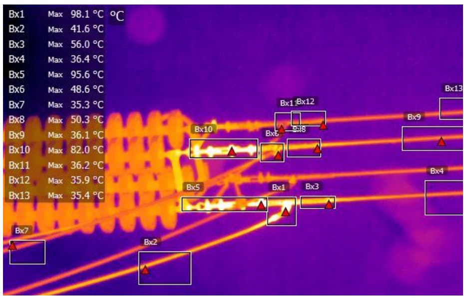

Figure 3. Inspection Results of Phase R at Tower 168, Directed Toward Tower 167

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2.3. JSA Hotspot PDKB

Several factors contribute to the occurrence of hotspots, including improper or loose connections in the conductor jumper clamps and link adjusters, poor quality materials in the clamps and adjusters resulting in high resistance, interference factors, excessive load on the bay, and resistance caused by pollutants in residential areas and the humid environment of the location. There are three approaches to addressing these hotspot anomalies, both offline and live-line:

- Cleaning the connection plates
- Adding more jumpers at the connection points
- Replacing old equipment with new ones

To identify the causes of hotspots and determine whether PDKB (live-line work) can be performed, a Job Safety Analysis (JSA) and climb-up inspection of the problematic tower must be conducted. The following data were collected during the JSA activities:

- Distance between the R-phase jumper and the R-phase cross-arm: 4 m
- Main angle iron - jumper clamp & link insulator: 6 m
- Length of the insulator string set: 5 m
- Jumper clamp bolt size: 19 mm

After performing the JSA and conducting a work safety analysis, it was concluded that the PDKB method could be implemented in the field, considering that this is a high-load line and no outage permission was granted by UP2B. As a result, actions were taken in compliance with PT. PLN (Persero) standards, specifically cleaning the connection plates using the PDKB method.

2.4. Instructions for Using Ohm Stick Plus

Several factors contribute to the occurrence of hotspots, including improper or loose connections in the conductor jumper clamps and link adjusters, poor quality materials in the clamps and adjusters resulting in high resistance, interference factors, excessive load on the bay, and resistance caused by pollutants in residential areas and the humid environment of the location. There are three approaches to addressing these hotspot anomalies, both offline and live-line:

The Live-Line Micro-Ohm Meter Ohm Stick Plus is designed to be directly installed on energized high-voltage lines, providing immediate resistance readings in micro-ohms. The Ohm Stick Plus can be used in almost all utility connections. Line connections can be tested after installation or after years of use. Switches, disconnection points, and separators that are typically open and have been open for a long time can be measured immediately after being closed. Each connection can be quickly tested after installation or surveyed after prolonged use to ensure proper connection resistance.

The Ohm Stick Plus is attached to a universal stick and pressed against the connection or connector so that the tested connection is positioned between the two electrodes. Within seconds, the instrument is removed from the line, and the current and line resistance readings are displayed on the instrument's front panel. The Ohm Stick Plus is designed to store up to nine sets of readings. Below are the steps for measuring with the Ohm Stick Plus:

- **Measurement**
  Place the Ohm Stick Plus on a conductor carrying at least 2 A of AC current, as shown in Figure 4. It is crucial to establish contact between the conductor and the voltage sensor, specifically the V-shaped plate between the jaws, and the voltage probe. The measurement begins as soon as the Ohm Stick Plus is positioned and stabilized.

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Figure 4. Installation of Ohm Stick Plus

Be cautious to ensure that the instrument remains stationary during measurement. Keep the Ohm Stick Plus in position for at least five seconds to allow for accurate measurement. While the Ohm Stick Plus is performing the measurement, the word "Sampling" will appear on the display. Once the measurement is complete, remove the Ohm Stick Plus from the conductor and review the readings displayed on the screen.

Figure 5. Ohm Stick Plus Measurement Results

- **Multiple Measurements**
  For resistance measurements at multiple points, repeat the initial steps for each point. The bottom-left box on the screen indicates the storage slot being used for each measurement.

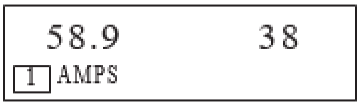

Figure 6. Ohm Stick Plus Screen Display

- **Viewing Measurement Results**
  To view measurement results, press and hold the control button until the following display appears:

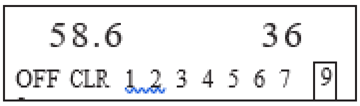

Figure 7. Reading Storage Display

When the button is pressed, the cursor will navigate through menu options at the bottom of the screen. To view any specific reading, release the button when the desired option is highlighted by the cursor.

- **Deleting Measurements**
  Press and hold the control button until the main screen appears with the messages "Power

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off," "Clear Data," and options numbered "1" to "9." Release the button when the cursor scrolls to the "Clear Data" option. A confirmation screen will appear:

Figure 8. Deleting Stored Data

Press and hold the control button until the selection box highlights the desired function. Release the button when the cursor scrolls over the "YES" option. All stored data will now be deleted.

- **Power Off**
  Press and hold the control button until the main screen appears with the messages "Power off," "Clear Data," and options "1-9." Release the button when the cursor scrolls to the "OFF" option. A confirmation screen will appear:

Figure 9. Turning Off the Device

Hold the control switch as the cursor scrolls through the "NO/YES" menu. Release the button when the cursor is over "YES." The Ohm Stick Plus will now power off. The device will automatically shut down if left inactive for 20 minutes.

3. Results and discussion

3.1. Thermovision Analysis Results

Thermovision measurements and data collection were repeated by JSA personnel from the PDKB UPT Bandung team. Measurement points included inner and outer terminal jumpers as well as inner and outer dead-end compression clamps on Conductor I Phase RST. For the thermovision analysis, the ΔT criterion equation was applied specifically to connection points between clamps and conductors.

Based on the temperature comparison data between connection objects and conductors, two objects on Phase R exhibited hotspot anomalies Outer string terminal jumper clamp: 26°C and Inner lower string terminal jumper clamp 128,4 °C Additionally, the **link adjuster**, which is not designed to carry electrical current, recorded the highest hotspot anomaly with a temperature of 123,3 °C, below is a summary of the data and recommendations for follow-up actions:

Table 1. Temperature Comparison Results and Evaluation

Hotspot Object		Temperature Difference (°C)	Recomendation
Outer Lower Ring	Clamp	26	Planned repair (max 30 days)
	DEC	29,6	Planned repair (max 30 hari)
	Link	95,6	Emergency condition
Inner Lower String	Clamp	128,4	Emergency condition

DEC	40,8	Immediate repair
Link	123,3	Emergency condition

3.2. Thermovision Analysis Results

Based on the hotspot comparison analysis, repair recommendations must be implemented immediately by the PLN UPT Bandung maintenance team. Considering that the transmission line cannot be de-energized by UP2B, the live-line work method becomes the priority in this case. From the survey conducted by the PDKB team, it was concluded that the PDKB method can be utilized to repair the hotspot anomaly on Tower 168 SUTET 500KV BDSLN-MDCAN T.168.

- **LLMAD and MTID**

  The results of the Job Safety Analysis (JSA) will be compared with calculations for Live Line Maintenance Approach Distance (LLMAD) between Phase-to-Phase and Phase-to-Ground, as well as the Minimum Tools Insulation Distance (MTID). These calculations will determine whether the PDKB method is feasible for use in this case.

  Known Data :
  C1 = 0,01ft/kVrms
  C2 = 1.1
  α = 0
  VF-F = 550kV
  VF-G = 550kV /√3= 318kV
  T = 150kV-275kV (3 p.u) 500kV (2,4 p.u.)
  Ketinggian = 115 + 60 m maka A = 1
  M = 0,3 (m)

  For the calculation of LLMAD F-G, which will be used as a reference for the distance between the conductor and the nearest ground, refer to equations (2.6), (2.7), and (2.8) in the following calculations:

$$V_{peak} = 318.2{,}4.\sqrt{2}$$
$$V_{peak} = 1079{,}32\ kV$$
$$\alpha = \frac{1079{,}32 - 675}{125000}$$
$$\alpha = 0{,}00323456$$
$$LLMAD_{F-G} = 0{,}3048\left[\left((0{,}01 + 0{,}00323456).(318).2{,}4.1\right) + 0{,}3\right]$$
$$LLMAD_{F-G} = 3{,}378\ m$$

  For the calculation of LLMAD Phase-to-Phase, which will be used as a reference for the distance between the conductor and the nearest conductor above and below Phase S, refer to equation (2.7) in the following calculation:

$$LLMAD_{F-F} = \left[\left(\left(\frac{8}{\left(\frac{4875}{1{,}35\ .\ 2{,}4 + 0{,}45.550}\right) - 1}\right)1\right)\right] + 0{,}3$$
$$LLMAD_{F-F} = 6{,}005m$$

  For the calculation of MTID, which will be used as a reference for the distance between the conductor and personnel during maintenance work, refer to equation (2.8) in the following calculation:

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$$MTID = 0{,}3048\left[\left((0{,}01\ x\ 1{,}1 + 0{,}00323456).(318).2{,}4.1\right)\right]$$
$$MTID = 3{,}311m$$

Based on the calculations and the JSA results, it can be concluded that the PDKB method can be implemented for the hotspot anomaly case involving the conductor jumper clamp and link adjuster on SUTET 500KV BDSLN-MDCAN T.168 Direction 167 Phase R, as it meets the requirements for PDKB work.

- **Equipment Preparation**
  In this activity, personnel prepare safety and work equipment based on the JSA results outlined in the Work Planning Analysis (AKP). The selection of equipment ensures that the tools used are appropriate for field conditions. This prevents excessive or insufficient equipment from being brought. Insufficient tools could hinder work progress, while excessive tools could burden personnel unnecessarily.
  mproper equipment selection impacts both personnel comfort and safety, as well as the electrical system's functionality. Therefore, selecting the right tools is a critical sub-process in PDKB work. The following factors should be considered when selecting tools:
- **Safety Working Load**
  The SWL is crucial when selecting tools, as they must withstand heavy loads that could potentially cause mechanical failure. Ensuring the SWL of tools safeguards personnel from mechanical risks.
- **Insulation**
  Insulation tools must withstand high voltages to ensure personnel safety from electrical failures. Hot sticks must handle at least 100 kV per foot. Therefore, the insulation length must be carefully calculated to handle the working voltage.
- **Visual Condition**
  Inspecting the visual condition of tools helps detect mechanical damage or resistance issues. Insulation strength is tested using a hot stick tester. Ensure there are no defects that impair the tool’s functionality.
- **Insulation Tool Testing**
  Good insulation tools must have a shiny, scratch-free surface. Carbon deposits on the insulation surface must be removed using a clean cloth and silicone to clean and coat the surface. Insulation sticks are tested with a hot stick tester to measure leakage current per foot.

For live-line ropes, physical conditions should not include excessive broken fibers to ensure the SWL remains adequate. Moisture content should also be checked, as high moisture levels could cause the rope to ignite under high voltage. Rope testing is performed using a rope tester to measure the rope's integrity per foot.

- Hotspot Repairs Using the PDKB Method
  Maintenance work using the PDKB method requires blocking the Auto-Reclose Relay (AR) on both adjacent substations according to SOP 7.001 for PDKB work. This ensures that, in the event of insulation failure causing a phase-to-ground connection, the protection system can immediately trigger a final trip.

During this stage, the team uses PDKB ropes to lift all equipment and installs them. Once all tools are in place, the hot end man measures conductor current, jumper current, and jumper clamp resistance on both string sets.

Hotspots on the BDSLN-MDCAN T.168 Phase R direction T.167 involve the jumper clamp, DEC, and link isolator on both the outer and inner lower strings. These hotspots are caused by pollutants entering the gap between connection plates and loose clamp bolt torque. Pollutants increase resistance at the conductor jumper clamps, while loose torque also raises resistance.

Using the OhmStik Plus, current and resistance measurements are taken at each joint on the string set. Measured points include DEC-conductor, jumper clamp-conductor, and link connections with temperature increases. Measurements start with the string set experiencing the highest temperature rise and proceed to the lowest. Steps for Using the OhmStik Plus:

a. Attach the probe (tail) to the OhmStik Plus.
b. Turn on the device by holding the button for a few seconds.
c. If the device memory is full, delete stored data by selecting the “Clear Data” option.
d. After clearing data, wait until the device displays “Ready” before measuring.
e. Place the main probe on the conductor and the secondary probe (tail) on the DEC. Ensure the DEC-conductor junction is centered between the two probes.
f. Hold for a few seconds until the device displays the measurement results. If the device shows negative current values, the current reading orientation is reversed.
g. Repeat steps 5 and 6 to measure jumper clamp-conductor and link connections, as well as other points on the string set.
h. Monitor available memory slots before measuring. If the device displays “Full,” repeat steps 3 and 4 before proceeding.

Based on the measurements taken using the OhmStik Plus, the table below presents the measurement results at the work points:

Tabel 1. Hasil Pengukuran Sebelum Perbaikan

Measurement Object		**Resistance (μΩ)**	**Current (A)**
	Clamp	722	183
Inner Lower String	DEC	21	165
	Link	2500	17,9
	Clamp	1500	147
Outer Lower String	DEC	16	162
	Link	2500	17,9
	Clamp	111	162
Inner Upper String	DEC	17	162
	Link	-	-
	Clamp	47	166
Inner Upper String	DEC	16	166
	Link	-	-

In the thermovision and OhmStik Plus results, the ΔT\Delta TΔT value for the inner lower clamp was 128.4∘C128.4^\circ C128.4∘C with a resistance of 722μΩ722 \mu\Omega722μΩ, while the outer lower clamp showed a ΔT\Delta TΔT value of 26∘C26^\circ C26∘C with a resistance of 1.5mΩ1.5 m\Omega1.5mΩ. Resistance measurements of the jumper clamps were carried out using the OhmStik Plus without de-energizing the system. The measured current for the outer lower string was 162A162 A162A, and for the inner lower string, it was 183A183 A183A. The following is an illustration of the measurement using the Ohm Stick Plus:

Figure 10. Measurement Before Repair

From the measurement results, it was found that the cause of the hotspot was the high accumulation of dust and dirt in the jumper gaps, which caused the temperature to rise. The method for repairing this issue involves opening the jumper clamp and cleaning it using steel wire and sandpaper. Once cleaned, reattach the jumper, then measure the conductor current, jumper current, and clamp resistance, and perform a temperature measurement on the clamp to ensure it is in normal condition.

Figure 11. Cleaning Dirt from the Jumper Clamp

After the conductor jumper clamp was repaired through cleaning, the temperature of the clamp was measured. The cleaning aimed to reduce the high resistance in the jumper clamp gaps. From the PDKB method repair, the resistance and temperature results after the repair were obtained.

Figure 12. Measurement After Repair

The measurement results showed that the resistance of the outer string jumper clamp was 22 μΩ with a current load of 167 A, and the resistance of the inner string jumper clamp was 17 μΩ with a current load of 166 A. The temperature readings can be seen in the following thermovision image.

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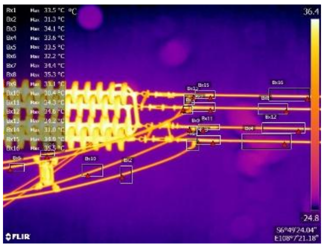

Figure 13. Temperature Measurement After Repair

From the results of this hotspot repair using the PDKB method, it was observed that the temperature of the jumper clamp decreased, eliminating the hotspot at that point. The temperature of the jumper clamp now has a small ΔT. In accordance with SKDIR 520, regular inspections are recommended.

3.3. Review of Abnormal Hotspot Repairs

The repair of abnormal hotspots or standard hotspot repairs at PLN UPT Bandung utilizes the OhmStick device with the PDKB method. This tool measures current, resistance, and the direction of current at the points being tested. Measuring resistance and current direction along with their values allows us to map the current flow and identify the source of the hotspot. It is possible that the point experiencing the hotspot anomaly is not the actual source of the issue.

The key benefit of using this tool is ensuring that the repaired point is indeed the source of the hotspot. Another advantage of the OhmStick is that personnel working on live voltage areas do not need to repair all strings, making the process more efficient. The use of the OhmStick is highly recommended in this case, as the point with the most significant hotspot anomaly is not the root cause. It would be impractical to repair the link experiencing the anomaly directly.

In the case of the hotspot at SUTET BDSLN-MDCAN T.168 Phase R, the abnormal hotspot occurred on the link isolator. Under normal conditions, the link does not carry current, so a hotspot anomaly would not appear. In this case, the current passing through the link is due to current distribution between the jumper conductor and the link at the jumper clamp point. This condition is illustrated in the diagram below:

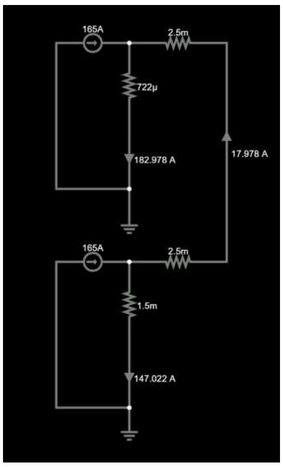

Figure 14. Circuit Model of Hotspot Anomaly

As we know, current flows from high potential to low potential along the path with the least resistance. Branching in a circuit divides current inversely proportional to the resistance values. The diagram above shows that the current passing through the inner lower conductor is divided

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towards the outer lower jumper conductor, which passes through the link isolator. This occurs due to a significant contact resistance difference between the outer and inner lower clamps. Consequently, a portion of the current passes through the link isolator, generating heat because the link material is not designed to conduct electricity.

From the data on the causes of the hotspot on the link, the solution is to reduce the resistance of the outer and inner string jumper clamps. This ensures that a small portion of the current from the inner lower clamp is not redirected to the outer lower clamp via the link. Measurements revealed that the hotspot was caused by high levels of dust and dirt in the jumper gap and loose clamp bolt torque, which increased the temperature. The repair steps involved cleaning the outer and inner lower jumper clamps and tightening all jumper clamps with a torque wrench. This was intended to lower the resistance of the outer and inner lower jumper clamps. By balancing the resistance between the outer and inner clamps, no current crosses the string via the link isolator.

After repairing the conductor jumper clamp by cleaning and tightening the bolts, the resulting current flow was reduced sufficiently, eliminating hotspots on the link in the string set isolator. The normal condition of the lower string circuit is illustrated in the following diagram:

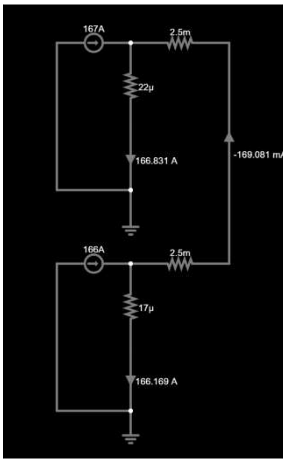

Figure 15. Normal Circuit Model

3.4. Analysis of Hotspot Disturbances

If a hotspot anomaly is left unaddressed and the influencing factors continue to increase the heat, it can develop into a disturbance. Hotspot disturbances pose a serious threat to the electrical system as they can lead to severe losses. These losses include the interruption of power flow between substations (GI) until normalization is achieved, as well as material losses due to the replacement of components melted by excessive heat. Interruptions in energy transmission will impact the receiving substation due to the loss of its power source.

Excessive heat causes the physical condition of components carrying electrical current to melt. This melting results in the components losing their mechanical strength. When components lose mechanical strength, they can cause a disruption in power transmission as the jumper conductor becomes disconnected from the conductor line. The disconnected jumper conductor will sag and may touch the phase cross-arm below it, which is connected to grounding at the tower's base. This will result in a phase-to-ground fault detected by the protection system.

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Figure 16. Melted Transmission Component

3.4.1. Subsubsection

Bulleted lists look like this:

- First bullet;
- Second bullet;
- Third bullet.

Numbered lists can be added as follows:

a) First item;
b) Second item;
c) Third item.

The text continues here.

3.5. Figures and tables

All figures and tables should be cited in the main text as **Figure 17**, **Table 3**, etc. Place figures as close as possible to the text they refer to and aligned center. Photos, graphs, charts or diagram should be labeled Figure (do not abbreviate), and assigned a number consecutively (**Figure 17**). The title should appear underneath the figure, aligned center, no additional blank line.

In cases where the title needs to be extended over to the second line, the title should be aligned left.

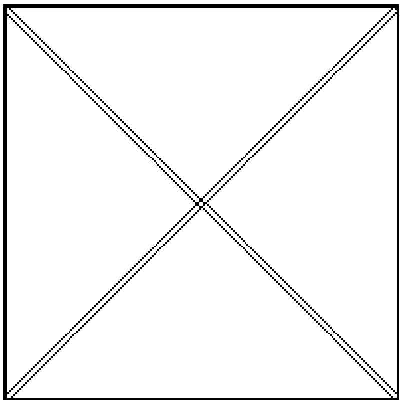

Figure 17. Figure lable.

Table 3. This is a table.

Title 1	**Title 2**	**Title 3**
Entry 1	data	data
Entry 2	data	data
Entry 3	data	data [1]

[1] Tables may have a footer.

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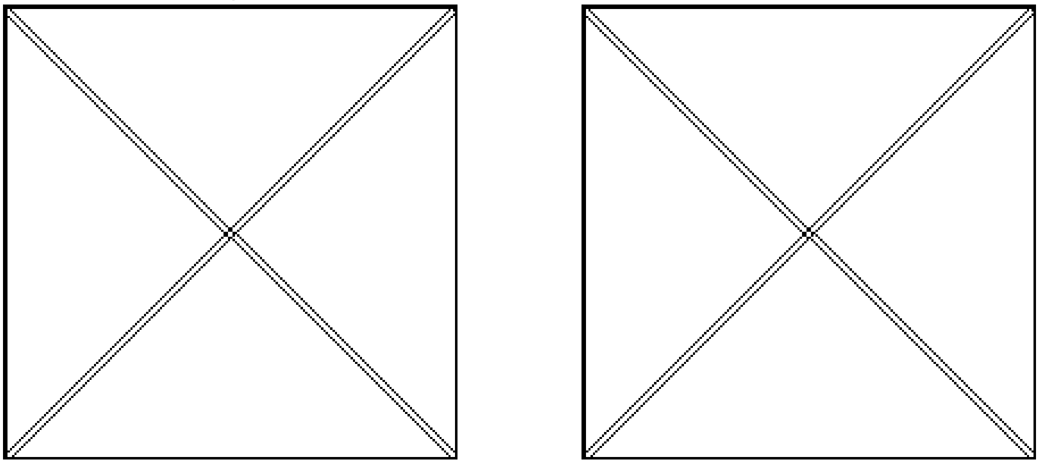
In cases where the tables need to be extended over to the second page, the continuation of the table should be preceded by a caption, e.g., "**Table 17.** (*Continued*)". Footnotes in tables should be written in superscript lowercase letters and placed below the table.

The text continues here (**Figure 18** and **Table 4**).



(a) **(b)**

Figure 18. This is a figure. Schemes follow another format. If there are multiple panels, they should be listed as: **(a)** Description of what is contained in the first panel; **(b)** Description of what is contained in the second panel. Figures should be placed in the main text near to the first time they are cited.

Table 4. This is a table. Tables should be placed in the main text near to the first time they are cited.

Title 1	**Title 2**	**Title 3**	**Title 4**
entry 1 *	data	data	data
	data	data	data
	data	data	data
entry 2	data	data	data
	data	data	data
entry 3	data	data	data
	data	data	data
	data	data	data
	data	data	data
entry 4	data	data	data
	data	data	data

[1] Tables may have a footer.

3.6. Formatting of mathematical components

Including symbols and equations in the text, the variable name and style must be consistent with those in the equations.

This is example 1 of an equation:

$$a = 1$$

the text following an equation need not be a new paragraph. Please punctuate equations as regular text.

This is example 2 of an equation:

$$a = b + c + d + e + f + g + h + i + j + k + l + m + n + o + p + q + r + s + t + u + v + w + x + y + z$$

the text following an equation need not be a new paragraph. Please punctuate equations as regular text.

Theorem-type environments (including propositions, lemmas, corollaries etc.) can be formatted as follows:

Theorem 1. *Example text of a theorem. Theorems, propositions, lemmas, etc. should be numbered sequentially (i.e., Proposition 2 follows Theorem 1). Examples or Remarks use the same formatting, but should be numbered separately, so a document may contain Theorem 1, Remark 1 and Example 1.*

The text continues here. Proofs must be formatted as follows:

Proof of Theorem 1. Text of the proof. Note that the phrase "of Theorem 1" is optional if it is clear which theorem is being referred to. Always finish a proof with the following symbol. □

The text continues here.

4. Conclusion and Recommendations

- The use of the OhmStik Plus in this case was for measuring resistance and current flow at connection points. The measured points included DEC-conductor, jumper clamp-conductor, and links experiencing temperature increases. Measurements began with the string set showing the highest temperature rise, followed by the lower temperature sets. The process started by attaching the probes, turning on the device, clearing stored data slots, and positioning the probes between the points to be measured. The measurement process was repeated for each connection point in every string set.
- The abnormal point in this case was the link isolator, which, under normal conditions, does not carry current and therefore should not exhibit a hotspot anomaly. As we know, current flows from high potential to low potential along the path with the least resistance. Branches in a circuit divide current inversely proportional to resistance. Measurements using the OhmStik Plus showed that the current from the inner lower conductor was partially diverted to the outer lower jumper conductor, passing through the link isolator. This occurred due to significant contact resistance differences between the outer and inner lower clamps, causing some current to flow through the link isolator and generate heat.
- From the data on the cause of the hotspot in the link, the necessary corrective action is to reduce the resistance in the outer and inner string jumper clamps. This will ensure that a small portion of the current from the inner lower clamp is no longer diverted to the outer lower clamp via the link. Measurements using the OhmStik Plus revealed that the hotspot was caused by high levels of dust and dirt in the jumper gap and loose bolt torque,

leading to increased temperature. The corrective steps involved cleaning the outer and inner lower jumper clamps and tightening all jumper clamps with a torque wrench. This reduced the resistance in the outer and inner lower clamps, balancing the resistance and preventing current from crossing the string via the link isolator.

- Excessive heat causes the physical condition of components carrying electrical current to melt. This melting results in the components losing their mechanical strength. When components lose mechanical strength, it disrupts power transmission as the jumper conductor becomes disconnected from the line conductor. The disconnected jumper conductor sags and may touch the phase cross-arm below or the tower body, both of which are connected to grounding at the tower base. This will cause a phase-to-ground fault detected by the protection system.

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