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Anomalies in the 110 VDC System at PT. PLN (Persero) Transmission Service Unit and Binjai Substation

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ABSTRACT
Anomalies in the DC system, both in the rectifier and the battery, will occur sooner or later, and the cause is equipment age, maintenance, and fault. The purpose of this study was to determine the anomaly that occurred in the 110 VDC system at PT. PLN ULTG Binjai. The research method is to observe, examine and measure the DC system. The research was carried out at the Paya Geli Substation and Pangkalan Brandan Substation. From the results of the study, it was found that the anomaly that occurred in the 110 VDC system at ULTG Binjai was the final voltage per battery cell which was less than 1 volt, namely the battery cell numbers 1, 34 and 39 in the Payageli substation 2 bank battery. DC ground occurs in bank 1 at the Paya Geli substation with the negative side connected to ground, the positive side voltage to ground is 95.2 volts, while the voltage on the negative side to ground is 8.4 volts. The main fault (phase loss) anomaly at the Pangkalan Brandan substation was due to the burning of the input line in the rectifier control module, causing the rectifier to fail and the DC supply from the rectifier to be lost and temporarily supplied by the battery. Regular maintenance is required for reliability to avoid anomalies and immediately recondition if the battery capacity is less than 60% and the final voltage per battery cell is less than 1 volt.

Keywords : ***anomaly, rectifier, battery, DC, ground***

INTRODUCTION

Operations at substations concern the supervision, recording, control and adjustment of the operating conditions of all equipment, daily patrols, minor repairs and emergency measures in case of disturbances. The activity aims to maintain the reliability of electricity so that it can still supply electricity to consumers in accordance with applicable regulations. To carry out this purpose, the substation is equipped with the necessary facilities and equipment in accordance with its purpose and has facilities for operation and maintenance, one of which is DC system equipment. The DC system at the substation is the heart or main key in operating control and protection equipment. So that if the DC current supply work system is disturbed or does not work, the control and protection equipment cannot be operated. This will result in the electricity distribution system being blacked out (dead), and there may even be damage to the substation equipment. The case is not expected to occur at a substation. Therefore, a proper and well-planned anticipation is needed so that the DC current source continues to function.

Disturbances or anomalies in the DC system that may occur must be known and detected so that a solution is found for this research to be carried out. Some of the substations that suffered severe damage due to interference, due to the failure of the 20 KV feeder OCR, the 20 KV incoming OCR and the 150 KV side OCR, were caused by the loss of a 110 volt DC source voltage for all such OCR. Protection failure at 150 kV substations is caused by DC voltage supply, which is a 110 VDC battery. DC systems can cause protection failures resulting from the absence of DC voltage supplying to protection and mechanical relays. Causes the

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relay to be unable to give the trip command to the PMT. (Sugianto, 2018). DC ground is one of the anomalies that often occur in substation DC systems. DC ground means the presence of one or more positive and negative side cables in the DC system connected to the ground system which causes a voltage imbalance between the negative and positive sides, where under normal conditions the magnitude of the positive and negative side voltages is the same. (Ariana W., 2015).

LITERATURE REVIEW

The 110 V DC power supply is a very important equipment and must be considered. if there is a disturbance in this system, it will cause black out and can endanger and damage the equipment at the substation such as pmt, pms and other protection equipment (Widiawati A., 2019). An anomaly is an aberration or strangeness that occurs or in other words is uncharacteristic. An anomaly is also often referred to as an event that cannot be estimated so that something that happens will change from the event. An example of an anomaly is a water anomaly where the volume of water will increase (instead of decrease) if it is at a temperature of < 4°C.

Some of the anomalies that occur in the 110 VDC ULTG Binjai system are:

- DC ground bank anomaly 1 GI Payageli
- Anomaly of phase lose rectifier bank 2 GI Base brandan
- End voltage anomalies per cell of 2 GI Payageli bank battery

In general, the electric current coming from the plant and transmitted to the substation is in the form of alternating current. For this reason, the supply of the DC system at the substation is supplied by batteries and Rectifiers. (PLN, 2009).

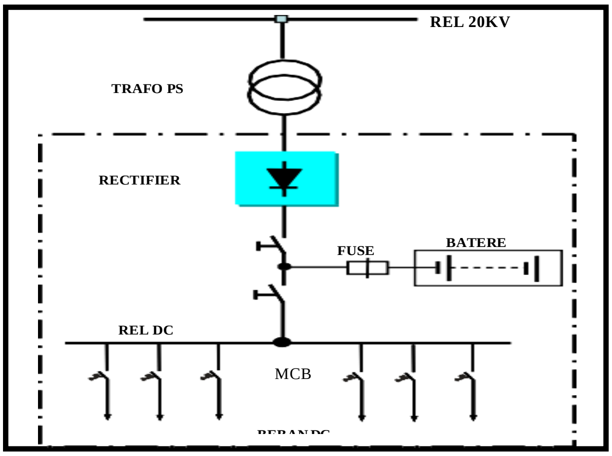

Figure 1. Simple Diagram of DC System Installation

If the rectifier malfunctions or there is no AC supply to convert then the DC supply will be supplied by the battery for several hours depending on how much Ah is installed.

a. Pattern 1

Pattern 1 consists of a PS transformer, 2 chargers, 2 batteries and 1 DC bus. The main safety and backup safeguards use different MCBs. Battery 1 and charger 1 (system 1) operate carry the load while battery 2 and charger 2 (system 2) operate without load. System 1 and system 2 operate interchangeably, this pattern is used in 150 KV Substations and 70 KV Substations.

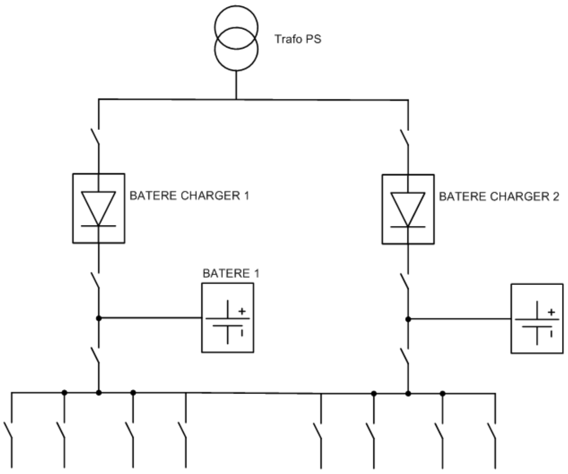

Figure 2. Pattern 1 DC System Installation

b. Pattern 2

Pattern 2 consists of a PS transformer, 2 chargers, 2 batteries and 2 dc buses main safety and backup safety using different MCBs. Pattern 2 is designed for 500 KV substations where with the philosophy of redundant protection so that the operating system battery 1 and charger 1 operate to carry the load of system 1 (main protection 1 and triping system 1) and battery 2 and charger 2 operate to carry the load of system 2 (main protection 2 and triping system 2). The normal position of system 1 and system 2 operate separately, mcb coupling position out. At the time of system 1 maintenance, the MCB of system 1 is removed then the coupling MCB will enter. And vice versa if the maintained system 2.

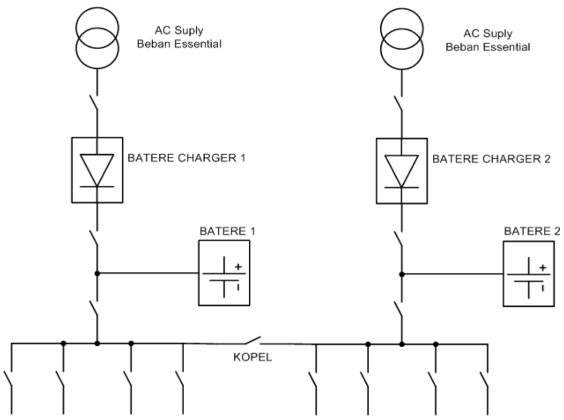

Figure 3. Pattern 2 DC System Installation

Substation DC System Installation

1. 250 VDC system installation

Used to distribute 250 volt DC supply supplied from rectifiers or three-phase chargers and connected with batteries to operate equipment in substation installations such as

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motors (PMT and PMS), protection relays, instruments, tripping and closing coils.

2. 110 VDC system installation
   Used to distribute the supply of 110 VDC supplied from rectifiers or chargers and connected with batteries to operate equipment at substation installations (Ricky A., 2016). The equipment displayed by the 110 VDC system such as motors (PMT and PMS), protection relays and digital meters, signals, alarms and indications, tripping and closing coils.
3. 48 VDC System Installation
   Used to distribute 48 Volt DC supply supplied from rectifiers or chargers and connected with batteries to operate equipment at substation installations such as scada / RTU, teleprotection units, communications (PLC), alarms, signals and indications.

Chargers are often also called rectifiers functioning to supply DC power both to equipment that uses a DC source and to charge the battery so that its capacity is maintained fully so that reliability at substations remains guaranteed. The main part of the rectifier consists of a Main Transformer, rectifier, AVR, Filter, Voltage Dropper Circuit, and alarm system. The main transformer as a voltage lowering from an AC voltage of 220/380 volts to 110 or 48 volts. The current capacity of the main transformer must be adjusted to the capacity of the installed battery and the load of the DC source at the Substation. The rectifier thyristor (controlled rectifier) serves as a rectifier and regulator of the output voltage of the main transformer, this rectifier is from a semi-conductor material equipped with one control terminal to regulate the ignition angle of the Thyristor.

Filters are used to level the current signal coming out of the rectifier and keep the DC voltage whose harmonic content or ripple voltage does not exceed a certain limit (<2%). This filter usually consists of a Capacitor component (Condenser) which is of the type Electrolyte or ELCO (Electrolyte Capacitor). The ac current that is equalized is not perfect into DC current and then filtered again by the Elco component (electrolite condenser) to maintain the stability of the electric current that enters the circuit for that if a capacitor or Elco is obtained in a condition that is not suitable for use, it will affect the way other components work because the DC electric current passing through the capacitor cannot be restrained or stored by it.

The use of capacitor components to filter or filter the ripples of the unfolding waves to obtain smooth and flat waves. AVR (Automatic Voltage Regulator) to produce a fixed and stable DC Voltage and Current, an AVR is needed that is installed on the rectifier and is an electronic module that functions to give a positive trigger to the gate thyristor so that the current and voltage settings of the rectifier output flowing to the battery and to the load can be adjusted as needed, not affected by temperature, load current and also the input voltage from the Output Filter. Voltage Regulators generally consist of Zener Diodes, Transistors or ICs (Integrated Circuits). Voltage dropper serves to maintain the stability of the output rectifier voltage towards the load when the rectifier operates on floating charging (battery installed above 86 cells), Equalizing or Boosting.

The rectifier output current and voltage regulation is carried out by setting the shear resistance on the control module (AVR) to meet the standards or conditions of battery charging and supply to the load. Alarm unit is an electronic device that functions to provide information when abnormal conditions occur in the rectifier work system, including:

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- AC Failure (Ac source input is disrupted)
- DC Failure (DC output interrupted)
- High DC Voltage
- Earth Fault Positive (Dc positive ground circuit disturbance)
- Negative Earth Fault (Negative DC ground circuit fault).

A battery is an electrical cell in which a reversible electrochemical process takes place with high efficiency. What is meant by the reversible electrochemical process is that in the battery there can be a process of converting chemistry into electric power (discharge process), and vice versa from electric power to chemical power (Charging Process), replenishment by regeneration of the electrodes used, namely by passing the electric current in the opposite direction (polarity) in the cell. Each battery cell consists of two different electrodes, namely the positive electrode and the negative electrode dipped in a chemical solution.

The batteries used at substations are generally nickel-cadmium (Ni-Cd) alkaline type batteries. The electrolyte material of the alkali is an alkaline solution (potassium hydroxide) consisting of Nickel-Iron Alkaline Batteries (Ni-Fe batteries) and Nickel Cadium Alkaline Batteries (Ni-Cd batteries). The general characteristics (depending on the manufacturer) are as follows:

- Nominal voltage per cell 1.2 volts.
- The specific gravity value of its electrolyte is not proportional to the capacity of the battery.
- Battery life depends on operation and maintenance.
- Charging voltage :
- Floating charging 1.40-1.44 volts.
- Rapid charging (equalizing) 1.50-1.60 volts.
- Charging at a high price (boosting) of 1.65-1.70 volts
- End voltage per cell 1 volt.

When the discharge or battery cell is connected with the load then, electrons flow from the anode through the load to the cathode, then negative ions flow to the anode and positive ions flow to the cathode. In the charging process, when the cell is connected to the power supply then, the positive electrode becomes the anode and the negative electrode becomes the cathode and the chemical process that occurs the flow of electrons becomes reversed, flowing from the anode through the power supply to the cathode.negative ions flow from the cathode to the anode and positive ions flow from the anode to the cathode.

The Main Parts of The Battery

1. Electrode

   Each battery cell consists of 2 (two) electrodes, namely the positive and negative electrodes, immersed in a chemical solution that functions as a medium for transferring electrons during charge discharge. The positive and negative electrodes are composed of several grids in the form of an iron frame that functions as a place for the active material. The active material functions as a material that reacts chemically to produce electrical energy.

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2. Electrolyte

   Electrolytes are liquids or solutions of chemical compounds that function to conduct electric current, the solution can produce both positive and negative electric charges. The positively charged part is called the positive ion and the negatively charged part is called the negative ion. The more ions an electrolyte produces, the greater the electrical conductivity.

   The type of battery electrolyte fluid consists of 2 (two) types, namely:

   - Sulfuric Acid Solution (H2SO4) is used on acid batteries.
   - Potassium Hydroxide (KOH) solution is used on alkaline batteries.

   Battery function in substations

   - Power sources for control tools, surveillance, signals and indicators.
   - Power source for PMT and PMS
   - Power source for emergency lighting, - Power source for protection relays.

The battery must always be connected to the rectifier so that it is always fully charged. The types of charging on the rectifier are: Floating, Equalizing and Boosting. Floating is charging to keep the battery in a full charger state and the battery does not discharge or receive electric current when it reaches the floating voltage and the battery remains connected to the battery and load. Equalizing is charging a battery to equalize or level the voltage because there is a difference in voltage of each cell. Boosting is a fast charging method that is used for initial charge or recharging the battery after the battery has experienced a large discharge or after a battery capacity test (capacity test).

DC System Maintenance

- Predective Maintenance

  Maintenance activities aimed at determining the condition of the equipment by predicting the equipment whether there is a possibility that the equipment will fail.
- Preventive Maintenance

  Maintenance activities are carried out at certain intervals, regardless of whether the condition of the equipment already requires maintenance measures or not.
- Corrective Maintenance

  Done by planning at a certain time when the equipment has abnormalities or low performance. This maintenance is also called Curative Maintenance.
- Breakdown Maintenance

  Maintenance is carried out after a sudden breakdown that is indeterminate in time and is an emergency in nature.

Monthly inspection of DC systems

- Checking the level of electrolyte, cleanliness of cells and battery racks.
- Inspection of the cleanliness of the main components, cooling fan, installation or cable holes and heater.
- Emergency lighting readiness checks, and wiring installations and holes.
- Inspection of the cleanliness of the battery room and the incoming air vent filter using a vacuum cleaner.

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Monthly measurements

- Voltage per battery cell using a Multimeter tool.
- Specific gravity of the electrolyte (acid batteries only) using a hydrometer.
- The current in the battery circuit on the wires between the battery cell racks uses ampere pliers.
- Volt AC input voltage meter using a multimeter.
- Load currents and batteries use ampere pliers.
- DC ground (110 volt system only) using a multimeter.

Measurement of the 6-month period

- Perform equalizing charging to the battery with manual operation.
- Equalizing voltage adjustment on the rectifier using Toolkit & Multimeter tool.
- Measurement of voltage per cell and total at the time of equalizing using multi meters.Thermovisi when charging equalizing to batteries, rectifiers and DC distribution panels using IR thermoguns.

METHODS

The research method is to make observations, examinations and measurements of the DC system. The research begins by collecting the data and equipment needed and then carrying out measurements and detections to then carry out problem solving.

Battery capacity testing

To find out the final voltage value of the battery cell is to test the battery capacity. Where this battery capacity test is included in the 2nd annual maintenance of the battery. using equipment in the form of toolsets, hydrometers, thermometers, multimeters, pliers, cleaning equipment, roll cables, capacity test equipment and laptops are tools used to test annual battery capacity. For annual battery maintenance using dummy load type ISA type TOOL BTS-100.

Figure 4. Dummy Load Test Equipment

Preparation in the form of preparing the tools needed in the work, wearing PPE (personal protective equipment), recording engineering data and tragging or labeling chargers and batteries, the purpose is to find out the condition of the charger, the current and voltage, the condition of the battery, find out the voltage, battery capacity (Ah) and the number of battery cells and then compare the condition of voltage, current, and capacity of the battery during the previous annual maintenance. doing tragging or labeling i.e. installing red and green flags on

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the equipment to be maintained (green flag means safe for maintenance work and red flag means danger to work on), placing a name or mark on the end of the cable relating to the equipment to be maintained.

Voltage checking, checking the level of electrolyte solution height, checking the temperature of the electrolyte solution of the standard battery cell temperature of the battery electrolyte solution when normal conditions are 25-34 °c, when maintenance is carried out: 34-37 °c, Check the specific gravity of the electrolyte solution because the electrolyte on the battery functions as a conductor or as an electron transfer medium therefore so that the chemical process in the battery works properly, then an examination or measurement of the specific gravity of the electrolyte is carried out.

The measuring instrument used is a hydrometer. Biennial maintenance is in the form of battery capacity testing, namely by knowing the amount of energy supply or battery capacity (Ah). The advantage of the battery capacity test can increase or restore the capacity (Ah) of the battery cell that is already weak, because after the battery is equalizing charge and at the time of the capacity test, the battery voltage discharge is carried out.The configuration of a battery in the main pool is, when there is one battery unit and one charger unit, this condition requires additional spare batteries so that the load supplied does not lose the voltage supply. since the battery tested is a bank battery of two Substations Payageli is to have only one battery then the way to test is only to remove the MCB or fuse that leads from charge to battery to prepare the battery from the system.

The test steps are:

1. Equalizing charge is done so that the voltage of each battery cell is the same and the battery is in full condition. This is done because it will test the capacity of the battery so the requirement is that the battery is in full condition (in the floating charge state) which is set on the rectifier panel
2. Open the MCB or open the fuse towards the battery using a puller device, so that the battery circuit is separated from the rectifier installation because the battery capacity test is a test to determine how much energy the battery can store until the battery is discharged and also so that the battery charge does not continue to start the battery capacity test.
3. Use ampere pliers to see if there is still current flowing into the battery, this is done to prove that the battery is completely separate from the charge (rectifier)
4. Use a multimeter to measure the overall voltage of the battery.
5. Prepare a Dummy Load Test equipment to test battery capacity.
6. Install the grounding first then install the power cable for the test equipment, then install the load injection cable at the ends of the battery cell, where there are 2 (two) load injection cables, namely red and black.
7. Then turn on the (On-kan) Dummy Load Test. Before starting battery capacity testing, there are several things that we must set, namely V (voltage), I (current) and t (time) to be set on the battery capacity test equipment (dummy load). Dc battery data 110 volt bank 2 GI payageli brand Saft, type SCM211, Capacity 211 Ah, number of cells 86 units. The following is how to calculate V, I and t (time) to be set on the battery capacity test equipment (dummy load), Voltage setting: V = 1 volt x number of battery

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cells, V = 1 volt x 86, then the voltage setting is 86 volts, Current setting: I = battery type x battery capacity, Payageli substation bank battery 2 is included in the C5 type, where C5 is 0.2 has been standardized by IEC (International Electrical Commission). I = 0.2 x 211, then the current setting is 42.2 Amperes, t setting = C5 where C5 = 5 hours.

8. After finishing setting the V (voltage), I (current) and t (time) settings on the battery capacity test equipment (dummy load), press the start button on the test equipment to start the test.
9. The test begins with measuring V (voltage) using a multimeter in each battery cell and the entire battery charged in the form, this measurement is carried out once every 1 (one) hour.
10. Note the V and I contained in the Dummy Load Test display on the battery capacity test form every 5 minutes.
11. If the battery voltage on the test equipment screen has shown 1 volt per cell (Since the number of batteries is 86 cells, it means that the battery voltage on the test equipment screen is 86 volts), then the test has ended.
12. Rearrange the equipment to its initial condition according to the procedure, which begins with turning off (Off-kan) the test equipment, then removing the load injection cable that is batteryd, removing the grounding cable of the test equipment and stacking the test equipment as appropriate.
13. Close the MCB or reattach the fuse towards the battery using a puller, so that the battery circuit is reconnected with the charge (rectifier), for recharging.
14. This Re-boosting Charge process aims to make the battery capacity empty after the full capacity test is carried out. When going to re-boosting charge the temperature of the battery electrolyte solution must be checked, which means that when you want to re-boost the temperature of the electrolyte on the battery must be normal.
15. After the re-boosting charge process is carried out, the maintained battery is ready to enter the system again. wait for the voltage to be equal to the charger voltage. After the same voltage connect the existing charger cable to the battery pole.

The anomaly that occurs in the DC system of bank 1 Payageli Substation is DC ground where there is one polarity connected to the ground which results in an unbalanced voltage between positive and negative. For this reason, the activities carried out to follow up on these anomalies are tracking and repairing. This means tracking several positive and negative side cables connected to the ground, and after being found, follow-up is immediately carried out, either replacing the cable, or replacing the damaged terminal. This work is performed on the DC system in an operating state which means that the work in the DC system state does not go out.

DC Ground Detection

Preparing the tools needed in the work, Using PPE, Recording Technical Data and Tragging or Labeling chargers (rectifier), labeling rectifiers are Knowing the amount of voltage and current that comes out of the dri rectifier, Knowing the location and output of the rectifier leading to bank 1 or 2, Marking or labeling so that in the work it is not confused between bank 1 and bank 2 and as security for equipment and maintenance personnel, Voltage checking is to

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find out the type of DC ground, whether negative ground or positive ground. The equipment used by toolset, Multimeter for checking voltage, cable roll, Test equipment needed in DC ground tracking is the Megger BGFT (Battery Ground Fault Tracer) test tool.

Figure 5. BGFT Test Equipment

DC Ground Detection Measures

1. Voltage measurement, voltage measurement using a multimeter at the MCB output that leads to the load to determine whether the anomaly occurring is ground positive or ground negative. The measurement results were positive-negative 114 VDC, Positive-ground 95.2 VDC and negative-ground 8.4 VDC. From the results of voltage measurements, the anomaly that occurs is negative ground where the negative side to the ground voltage is very low compared to the positive side to the ground.
2. Prepare the Megger BGFT test equipment, Install the grounding of the tool in advance.
3. Connect the supply cord of the test equipment and make sure the position of the power switch of the appliance is in the On position
4. Frame each existing equipment cable according to the IK of the Megger test equipment in the following order:
   - Connect the black clip cable to the existing DC system grounding on the grounding bus.
   - Connect the cable of the clip of red color on the bus of the negative side, since the anomaly that occurs is negative ground.
   - Connect the feedback cable to the BGFT
5. Turn on the test tool with the following steps:
   - Set the voltage control at the minimum position
   - Set the voltage control switch to the disconnect position
   - Set all capacitance selectors to the minimum position
   - Set the resistance switch in the open direction
   - Move the power switch to the On position, after a pause of 30 seconds, the ready light will light up, then the test equipment is ready to operate.
6. Move the output voltage switch to connect
7. After paying attention to the display of the output voltage, slowly turn the voltage control so that the output current meter will show the desired signal current ratio.
8. Track each negative cable to find out the position of the interference using the receiver

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meter.

9. When the display on the receiver meter screen shows the same or close results as the current output meter display, the connected cable has been found.
10. Mark the cable with paper insulation or the like so that at the time of repair it is not confused
11. Dc ground tracking is complete and turn off the test equipment with the step of setting the voltage control completely to the fault, set the output voltage switch to disconnect and set the power switch to the Off position
12. Disconnect the red wire and then the black wire, disconnect the feedback cable and disconnect the supply cable of the test equipment

After the cable connected to the ground has been found and the equipment has been arranged as it should be, the next job is to follow up on the cable connected to the ground. After that measure the negative side voltage back to ground whether there has been a change or not.

Phase Lose Anomaly at Rectifier Bank 2 Brandan Base Substation

The anomaly that occurs in the rectifier bank 2 Substation Of The Brandan Base is a phase lose which results in the rectifier not supplying DC current at the load and also the charger for the battery.

Figure 6. Rectifier Indication Display

The follow-up is to trace the source of the problem why the rectifier can experience phase loss for that step that can be done.

1. Rectifier is non-operated, temporarily before repairs are carried out to avoid further damage.
2. The load is supplied by the battery, the battery installed in the DC system bank 2 supplies the load for the next few hours while waiting for repairs to the rectifier.
3. Installing a mobile DC
4. Rectifier that is non-operating means that it does not supply DC current to the load and battery, therefore to maintain the reliability of the DC system the rectifier is replaced by a mobile DC that is installed in parallel to supply the load and battery charger.
5. Voltage measurement on the input rectifier:

- Phase R to S : 380.7 VAC
- Phase R to T : 382.2 VAC
- Phase S to T : 379.4 VAC
- Phase R to neutral : 215.4 VAC
- Phase S to neutral : 219.3 VAC
- Phase T to neutral : 218.6 VAC
- Neutral to ground : 1,025 VAC

RESULTS AND DISCUSSION

DC Battery Capacity Testing 110 Volt bank 2 Payageli Substation

Battery capacity represents the amount of electric current (amperes) of the battery that can be supplied or flowed to an outside circuit or load within a certain period of time (hours). To find out whether the battery is fully charged and can store it properly, it is necessary to measure the condition of the battery by simulating a load that can be adjusted so that the current can be adjusted at a fixed current, the battery voltage will drop from the nominal. The voltage drop time is compared to the characteristics of the battery, it can be known the condition of the battery. In alkaline nickel-cadmium (NiCd) batteries generally the battery capacity is expressed in C5 which states the magnitude of the battery capacity in Ah available for 5 hours for C5.

Battery capacity test result 110 VDC bank 2 Payageli Substation

In the test of the battery capacity of 110 VDC bank 2 Payageli substation on February 19, 2019, the test results were obtained as follows:

1. Battery capacity

   The efficiency of a battery capacity is defined as the percentage ratio or ratio of the discharge capacity to the charging capacity of that battery .

   Battery efficiency calculation:

   $$n = \frac{\mathrm{Cd}}{\mathrm{Cc}}\ x\ 100\ \%$$

   Information:

   n = Efficiency (%)
   Cd = Discharge capacity (Ah)
   Cc = Charging capacity (Ah)

   The capacity of the battery at the time of testing (discharge) is 168 Ah, while on charging (name plate) it is 211 Ah.

   Then the battery efficiency :

   $$n = \frac{168}{211}\ X\ 100\ \%$$
   $$n = 0{,}7962\ X\ 100\ \%$$
   $$n = \mathbf{79{,}62}\%$$

   The battery capacity is said to be good from the manufacturer is >80%, and according to the PT Supplay AC/DC System Manual. PLN (PERSERO) battery capacity is said to be good if > 60%. The battery capacity obtained after being tested is 79.62% then

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the battery condition is in good condition, but according to the manufacturer it is still lacking because it is below 80%.

2. Final discharge voltage per cell

According to the PT. PLN battery condition is said to be good if the final voltage at the time of discharge is 1 volt per cell. After the discharge is then measured the voltage of each cell, 0.242 volts are obtained by 1 battery; 34 batteries of 0.241 volts; 39 batteries of 0.248 volts. The condition of the battery is called in a bad state because the final voltage is less than 1 volt.

At the Payageli Substation, the DC bank 2 system uses a 110 VDC battery with a battery capacity of 211 Ah, meaning that the battery is able to supply current for a DC load of 211 Amper in 1 hour. For example, the load of the equipment used at the Substation is 6 amperes, under normal conditions the 110 VDC battery should be able to bear the load for 35 hours and 9 minutes. However, because the condition of the battery capacity at the time of testing was 79.62% (168 Ah), the battery was only able to bear the load for 28 hours.

Battery capacity calculation:

$$\boldsymbol{C = I\ x\ t}$$

Information:

C = Battery capacity
I = Current strength (Amperes)
t = Time (Hours)

Then:

$$168 = 6\ x\ t$$

$$t = \frac{168}{6}$$

$$t = 28\ Hours$$

Causes of decreased battery capacity and final voltage per battery cell below 1 volt

- Float charging for too long
- Electrolyte fouling (contaminated)
- Carbon fouling/sediment
- The surface of the electrolyte is too low
- Emptying occurs in the cell (sparator) disturbances in the cell
- The charging voltage setting does not match the number of battery cells

The Anomali of the DC Ground Bank 1 Payageli Substation

DC ground is one of the anomalies that often occur in substation DC systems. DC ground means the presence of one or more positive and negative side cables in the DC system connected to the ground system which causes a voltage imbalance between the negative and positive sides, where under normal conditions the magnitude of the positive and negative side voltages is the same.

There are two types of DC ground, namely; Positive ground and negative ground. To distinguish is seen from the value of measuring the positive and negative side voltage.

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1. Positive ground
   This means that the positive side of the DC system is connected to ground, and if measured the positive voltage is much smaller than the negative side.
2. Negative ground
   It means that the negative side of the DC system is connected to ground, and if measured the negative voltage is much smaller than the positive voltage.

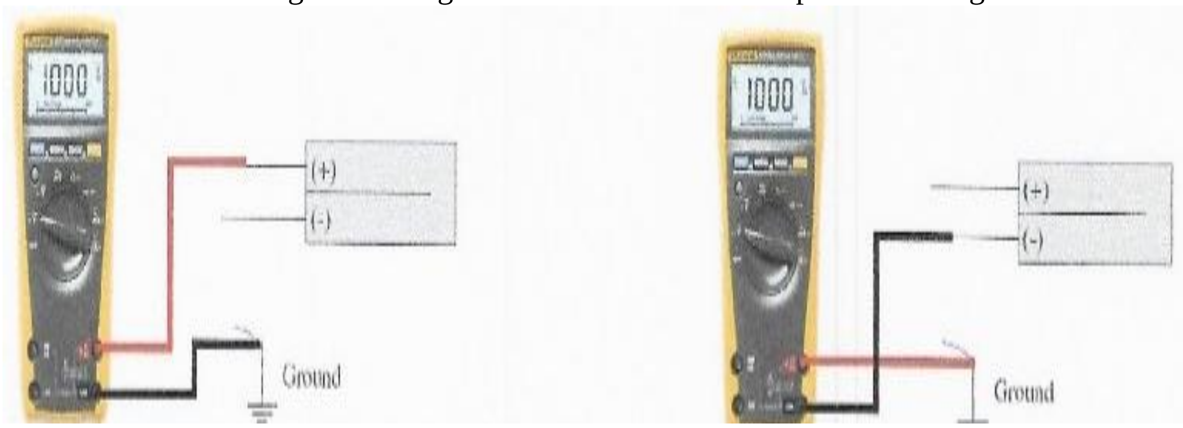

Figure 7. How to Measure Positive and Negative Voltages

The DC Ground limit according to PLN states that the safe limit of the DC Ground voltage is:

(50% x Vtotal) ± (12,5% x Vtotal)

Then the safe limit for a voltage of 110 VDC is:

(50% x 110 VDC) ± (12.5% x 110 VDC)
(55 VDC ± 13.75 VDC)
(55+13.75) = 68.75 volts
(55-13.75) = 41.25 volts

This means that the safe limit of the dc ground voltage on the 110 VDC system is 41.25 volts for the lower limit and 68.75 volts for the upper limit.

Follow-up negative ground bank 1 Payageli substation

After dc ground tracking, the anomaly that occurred in the 110 VDC system of bank 1 Payageli Substation was negative ground. When measured the positive voltage to ground is 95.2 volts where this condition has passed the safe limit of dc voltage. For this reason, follow-up is immediately carried out to maintain the reliability of the system at the substation, especially the protection system.

The point of cause of the negative ground is in the cable belonging to the UPB on the Power Transformer Protection Panel 1, with a marking of 110(-) tsd transformer1

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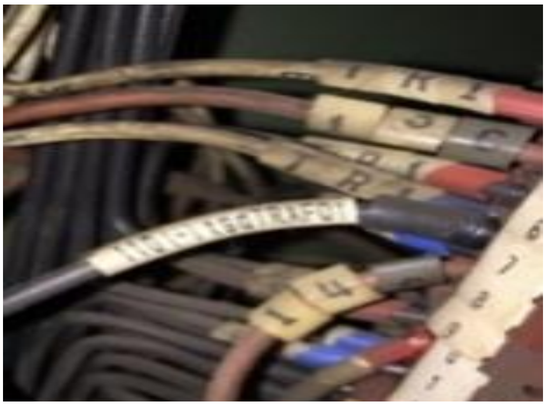

Figure 8. Cable Cause DC Ground

The follow-up was to remove the 110(-)tsdtrafol marking cable from the system. Data on the results of DC voltage measurement before and after follow-up is carried out as follows:

Before : (+) – Ground = 95.2 V
After : (+) – Ground = 85.1 V

Effect of DC Ground on 110 VDC systems

For a 110 VDC system whose grounding system is not ground, of course, neither one nor both polarities should experience a ground fault (leakage current connected to the ground). If one of the polarities is connected to the ground then it is very likely that the DC system will fall and if the two polarities are ground faulted then the system will trip due to the presence of a short circuit between positive and negative. And if this happens it will be very dangerous because this 110 VDC system is a supply for protection systems at substations.

Anomali Rectifier Bank 2 Substation Pangkalan Brandan

The phase lose anomaly that occurs in the rectifier after tracking by reading the wiring, checking the voltage and opening the rectifier panel found the cause of the anomaly in the rectifier bank 2 Pangkalan Brandan caused by a burning control module as shown in figure 9 below:

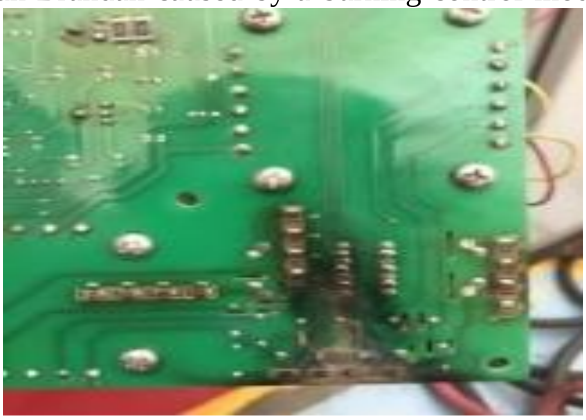

Figure 9. Burnt Rectifier Control Module

After the follow-up is carried out, namely the replacement of the burnt PCB module. Rectifier bank 2 can be operated and mobile DC can be removed by looking at the measurement

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data after the rectifier is operated.
Measurable data :
Rectifier voltage = 129.2 VDC
Battery voltage = 129.2 VDC
Load voltage = 116 VDC
Rectifier current = 9.5 A
Battery current = 4.5 A
Load current = 5.3 A
Positive voltage to ground = 66 VDC
Negative voltage to ground = 49 VDC

This means that there is a negative ground but it is still in a condition of safe limit voltage.

CONCLUSION

All protection and telecommunications equipment used in the farm uses DC sources for equipment work. The DC system at the Substation is supplied by a rectifier and also batteries that are connected in parallel with the load. Rectifier and battery maintenance and inspection include daily inspections, monthly inspections, six-monthly inspections, and biennial maintenance. Battery capacity is said to be poor if the efficiency of the battery capacity is below 60% and the final voltage per cell is below 1volt, An anomaly that often occurs in DC systems is a DC ground anomaly where one or both polarities are connected to the ground which results in an unbalanced voltage between positive and negative. The safe limit of dc ground voltage on a 110 VDC system is 41.25 volts for the lower limit and 68.75 volts for the upper limit. A 110 VDC system whose grounding system is not grounded if one of the polarities is connected to the ground, it is very likely that the DC system will fall and if the two polarities are ground faulted, the system will trip due to a short circuit.

SUGESSTION

Regular maintenance is necessary for reliability to avoid anomalies and recondition immediately if the battery capacity is less than 60% and the final voltage per battery cell is less than 1 volt.

REFERENCES

Ariana W., (2015), *Cara Mengatasi DC Ground (EF) Pada Sistem 110 VDC Dengan Cara Sederhana*, https://mataramelectric.blogspot.com/2015/06/caramengatasi-dc-ground-ef-pada-sistem.html, diakses 15 Juli 2020.

PLN, (2009), *Buku Pedoman Pemeliharaan Sistem Supplay AC/DC*, No. Dokumen: 1922/HARLUR-PST/2009.

Ricky A., (2016), *Studi Kapasitas Baterai 110 Vdc pada Gardu Induk 150 kV Bangkinang*, Teknik Elektro Universitas Riau, Pekanbaru.

Sugianto, (2018), *Kegagalan Proteksi Pada Gardu Induk 150 KV Akibat Suplai Tegangan DC*, Teknologi Industri Institut Sains dan Teknologi Nasional, Jakarta.

Widiawati A., (2019), *Analisis Gangguan Pada Sistem Kerja Power Supply DC 110 Volt di Gardu Induk Padalarang*, Bandung.