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Feasibility Study of Connecting Device for Low-Voltage on Transformer Mast Substation At PT PLN (Persero) UP3 Padang

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Abstract— **The feasibility study of the low-voltage connecting device at the transformer pole substation was conducted to determine the load conditions and feasibility of the Low Voltage Connecting Device (PHB-TR) when operating in the Jalan Beringin Raya Lolong Belanti area, North Padang District, Padang City. This study details several aspects such as PHB-TR construction, Type and rating value on PHB-TR, service conditions, PHB-TR components, and Transformer Pole Substation. The method used is by making direct observations and making measurements, then the measurement and calculation data compare with the applicable PLN standards. Modeling in research using ETAP software to determine Losses, in accordance with the load on the G. 248 T distribution substation PT. PLN (Persero) UP3 Padang. The results of research from two departments in PHB-TR G.248 T stated that the load on each department exceeded capacity during the day or when research was carried out according to health index criteria. Due to the large load obtained by many customers and the use of electronic devices during research, it is necessary to take action such as moving customers one phase at the highest load to one phase of the smallest. The stability and reliability of the devices in the panel must be safe and maintained for long-term use, it is necessary to select PHB-TR capacity that can accommodate additional customers or increased electrical loads that may occur and need planning and consideration in determining component capacity.**

Keywords— **Load Imbalance; Power loss.**

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I. INTRODUCTION

The use of electrical energy sources is getting higher along with the rapid demand for technological advances, today electricity has been used for various purposes both from households and even to the industrial world. Therefore, its continuity needs attention. To maintain the continuity of its distribution, a reliable and absolute electrical system is needed as needed. The electrical system is not spared from various disturbances, ranging from the generation process to the process of using it. Several ways have been done to overcome the disruption, the disturbances that occur will have an exclusive impact on the burden (consumers). Suppose there is a disturbance, then the distribution of electricity to the load will also be cut off. Low-Voltage Connect Device (PHB-TR) is a vital means in maintaining the smooth distribution of electricity from the PLN network to consumers or loads. And for that in designing a PHB-TR must follow the rules that have been standardized in the General Regulation of Electrical Installations 2000 (PUIL 2000). The eligibility criteria for PHB-TR depend on various factors including safety, performance, energy efficiency, durability, and compliance with the standard. Taking into account all the previous criteria, the selection of the right low-voltage connecting device can be made to ensure the electrical system operates efficiently, safely and reliably.

II. THE MATERIALS AND METHOD

2.1. Low-Voltage Connect Device (PHB-TR)

PHB-TR is a combination of one or more low-voltage connecting devices with interconnected control, measurement, safety and control equipment. The whole is assembled complete with maintenance and mechanical systems on the support parts. PHB-TR installed secondary side transformer of a distribution substation both Concrete Substation, Kiosk Substation, Portal Substation and Cantol Substation. The number of majors per transformer or distribution substation is a maximum of 8 majors, adjusted to the amount of transformer power and the Low Voltage Network Conductor (JTR) Current Conductivity (KHA) used. Types of PHB-TR outer pairs, as follows:

TABLE I
PHB-TR type out-of-pair

Tipe	Jumlah Jurusan	Arus Pengenal [A]			Kapasitas Transformator Maksimum [kVA]2)	Ketahanan Hubung Singkat 1 detik [kA]
		PHB-TR	Jurusan			
			Nominal	Maksimum1)		
1	2	3	4	5	6	7
PL-250-2-DDDD-EE	2	250	125	160	160	≥ 8
PL2-400-2-DDDD-EE	2	400	200	250	250	≥ 10
PL-400-4-DDDD-EE	4	400	100	160	250	≥ 10
PL-630-4-DDDD-EE	4	630	160	200	400	≥ 16
PL2-1000-5-DDDD-EE	5	1000	200	250	630	≥ 25
PL-1000-6-DDDD-EE	6	1000	160	200	630	≥ 25

(Source: SPLN D3.016-1: 2018)

Notes:
1. The maximum current of majors per phase, but the total current in all majors must not exceed the rated current of PHB TR column 3.
2. The MCCB switch must be able to protect the transformer. PL-250-2-MCCB type uses an adjustable type MCCB switch.

TABLE II
Temperature rise limits

Measured part	Temperature rise [K]
Main switch terminal	70
Test cable (measured 5 cm from the base of the cable shoe)	35
Manually operated equipment lever	
a) Metal materials	15
b) Non-metallic materials	25
The outer surface of the enclosure	
a) Metal materials	30
b) Non-metallic materials	40
Busbar connection – busbar	
Busbar connection – *fuse rail*	60
Fuse contact	60

(Source: SPLN D3.016-1: 2018)

Notes: Testing temperature increase using dummy NH-fuse link, with power dissipation refers to the rated acceptable dissipated power on the fuse base which is adjusted to the amount of test current used.

2.2. PHB-TR components

1. General requirements
   The clearance and propagation distance of the busbar system and components on PHB-TR based on SPLN D3.016-1:2018:
   - Minimum clearance : 5,5 mm
   - Minimum propagation distance : 6,3 mm
2. Main Switch Characteristics
   The characteristics of each main switch are listed in Table 3 based on SPLN D3.016-1:2018:

TABLE III
Main switch characteristics

Characteristics	Requirements			
PHB-TR rated current	250 A	400 A	630 A	1000 A
Load breaker switch				
Design standards	IEC 60947-3			
Utilization category	AC-22 atau AC-23 at rated voltage			
Rated current	≥ 400 A	≥ 500 A	≥ 800 A	≥ 1250 A
Short-circuit resistance	≥ 8 kA	≥ 10 kA	≥ 16 kA	≥ 25 kA
Locking facility	In the open position the switch can be locked			

Insulation material	Heat-resistant and self-extinguishing flames			
Contact coating materials	*Silver plated*			
Terminal coating material	*Silver plated*			
MCCB				
Design standards	IEC 60947-2			
Rated current	250 A	400 A	630 A	1000 A
Short-circuit disconnection capability	≥ 8 kA	≥ 10 kA	≥ 16 kA	≥ 25 kA
Locking facility	In the open position the switch can be locked			
Insulation material	Heat-resistant and self-extinguishing flames			
Terminal coating material	*Silver plated*			

(Source: SPLN D3.016-1: 2018)

The fuse rail is mounted on the montage board on the right side vertically. The sequence of phases on one fuse rail unit is:

- Phase R : up
- Phase S : middle
- Phasae T : buttom

Each fuse rail unit must be equipped with a department marker label.

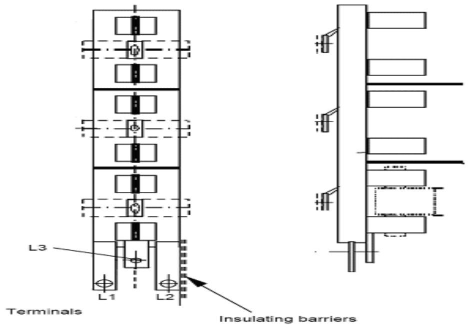


FIGURE 1. Fuse Rail

3. NH Fuse Link Characters

The characteristics of NH Fuse link on fuse rail are listed in Table 4 The size of NH fuse link to be used on PHB-TR must match the size of the installed fuse rail based on SPLN D3.016-1: 2018:

TABLE IV
NH fuse link characters

Characteristics	Requirements	
Design standards	IEC 60269-1 dan IEC 60269-2	
Class	gG or gL	
Rated voltage	400 Vac or 500 Vac	
Rated current	50 ; 63 ; 80 ; 100 ; 125 ; 160 ; 200 ; 224 ; 250	
Top and bottom cover material	Aluminium	
Contact coating material (blade)	*Silver plated*	
Contact blade length	Size 1	135 ± 2.5 mm
	Size 2	150 ± 2.5 mm
Maximum power dissipation	Look at table 6	

(Source: SPLN D3.016-1: 2018)

NH 1 = NH size 1;
NH 2 = NH size 2

TABLE V
NH fuse link power dissipation

Rated current [A]	NH 1 $^{1)}$ [W]	NH 2 $^{2)}$ [W]
50	5,5	5,7
63	7,1	7,1
80	8,4	8,5
100	9,2	9,7
125	12,4	12,8
160	15,3	15,7
200	18,3	18,3
224	-	19,2
250	-	21,0

(Source: SPLN D3.016-1: 2018)

2.3. Transformer Poles Substation (GTT)

Transformer poles substation (GTT) is one of the components of electrical power installations installed in the distribution network. Functions as a power transformer to reduce voltage from medium voltage to low voltage, and then the voltage is channeled to consumers. Given the functionality and price of the transformer is quite expensive when compared to other distribution equipment, preventive maintenance is carried out intensively with clear maintenance criteria for each GTT component and handled by skilled personnel with adequate equipment so that the maintenance runs effectively. GTT is located close to consumers, transformers are installed on electricity poles and integrated with the power grid. To secure the transformer and its system, GTT is equipped with safety units placed on PHB-TR The step-down power transformer serves to lower from medium voltage 20 kV to low voltage 380/200 V (reference transformer voltage 400/231 V).

Online Assessment Tier-1 matrix in the context of distribution transformers in Table 1. refers to the assessment process to measure the performance and reliability of the transformer. This is often done as part of a preventive maintenance program or routine performance evaluation to ensure transformers are operating optimally and meet safety and quality standards. In addition to live monitoring, the Tier-1 Online Assessment Matrix may also include the evaluation of historical data collected from transformers to identify patterns or trends that may indicate potential future problems. Using this approach, transformer maintenance and repair can be carried out proactively to prevent unexpected failures and ensure the continuity of safe and efficient operations.

2.4. GTT Grounding Measurement

Measurement of grounding resistance at the Distribution Substation uses position variations that are designed in such a way (0o, 90o, and 180o) so that accurate resistance measurement data is obtained. It is important to remember that soil resistance greatly affects the conduct of electricity in electrical installations, grounding systems, and so on. The higher the resistance of the soil, the lower the current that can flow through the soil, and vice versa. As for resistance or resistance, this refers to the resistance of an object or material to the flow of electricity. Resistance is measured in ohms (Ω) and is influenced by several factors such as length, cross-sectional area, and material type. Materials that have high resistance will slow down the flow of electricity more than materials with low resistance.

2.5. Measurement of Isolation Resistance

Knowing the amount of insulation resistance of an electrical equipment is important to determine whether the equipment can be operated safely To measure the insulation resistance used Mega Ohm Meter / Insulation tester. The insulation in question is insulation between parts that are voltage or with parts that are not voltage such as body / ground. Insulation tester is used to measure the insulation resistance of medium voltage and low voltage installations.

TABLE VI
KHA cable

No	Penampang Kabel (MM²)	Kuat Hantar Arus (Ampere)
1	0.75	12
2	1	15
3	1.5	18
4	2.5	26
5	4	34
6	6	44
7	10	61
8	16	82
9	25	108
10	35	135
11	50	168
12	70	207
13	95	250
14	120	292

(Source: Angewandte Chemie International Edition, 6(11), 951–952)

2.6. Distribution Substation Monitoring Application

This Distribution Substation Monitoring Application is an application made to assist PLN Officers in recapping data and monitoring Distribution Substations, especially in the distribution section of PT. PLN (Persero).

2.7. Software ETAP

ETAP (Electric Transient Analysis Program) is software used to analyze an electric power system. ETAP software can work offline (for simulating electric power systems) or online which aims to analyze data in real time (such as SCADA). ETAP software is very useful in electrical system planning. In ETAP, there are types of elements such as AC elements, instruments and DC elements. ETAP has 2 kinds of standards used to perform electrical analysis, ANSI and IEC. Basically, the difference that occurs between the two standards is the frequency used, which results in differences in equipment specifications that match these frequencies. The symbols of electrical elements used in the analysis using ETAP are also different.

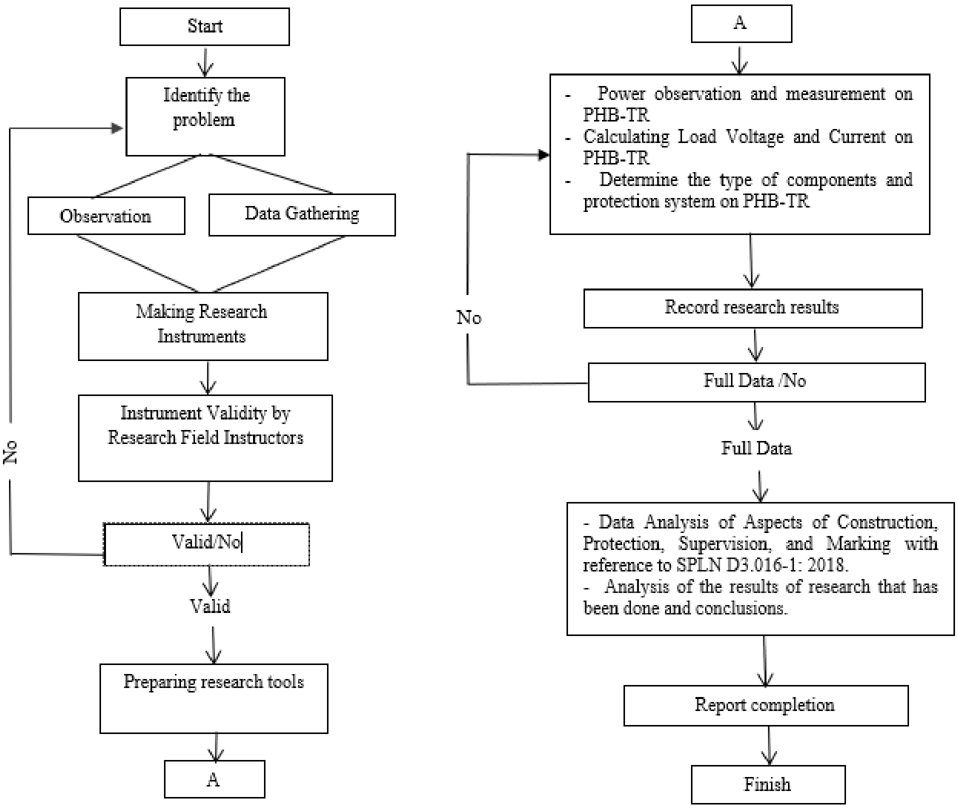
Description of GTT and PHB-TR G. 248 T PT PLN (Persero) UP3 Padang

In research G. 248 T PT PLN (Persero) UP3 Padang, the condition of GTT and PHB TR is still safe and still suitable for use for electricity needs for customers.

TABLE VII
G. 248 T PT PLN (Persero) UP3 Padang

Daya Trafo	160 kVA (2015)
Merek Trafo	SINTRA (PT. Sintra Sinarindo)
Lokasi	Jalan Beringin Raya No. 57 Lolong Belanti, Kecamatan Padang Utara, Kota Padang
Kontruksi Gardu	Double Pole (Portal)
Produksi PHB TR	PT. Panel Mulia Total

Research Diagram



FIGURES 2. Flowchart of Final Project Writing Work Procedure

Determining NH Fuse Current

Here is the formula for calculating NH Fuse current:

$$In = \frac{Transformer\ capacity\ (Volt.Ampere)}{\sqrt{3}\ x\ phasa{-}phasa\ Voltage\ (volt)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

$$\text{The Flow of Each Department} = \frac{In\ (Ampere)}{\sum Majors\ in\ PHB{-}TR} \quad \ldots\ldots\ldots\ldots\ldots\ (2)$$

KHA NH Fuse selected = The Flow of Each Department x 0,9 ……….. (3)

Note : The time factor of 0.9 is the safety factor for transformer loads.

Determining the Power of Each Department

Here is the formula for calculating the load power of each department:

1. Apparent Power

   Apparent Power is electrical power through a transmission or distribution conductor. This power is the result of the multiplication between voltage and current through the conductor.

   1 Phase ➔ $S = V_L\ x\ I_L$ …………………………………………….. (4)

   3 Phase ➔ $S = \sqrt{3}\ V_L\ x\ I_L$ ………………………………………… (5)

   Captions:

   S : Apparent power (VA); V_L : Network voltage (Volt); I_L : Network current (A)

2. Transformer Loading Percentage

$$\% \text{ Load on Department I} = \frac{kVA\ Total\ Department\ Load\ I}{kVA\ Transformer} \times 100\% \quad (6)$$

Inter-phase current imbalance

To find the Interphase Current Imbalance, use the formula:

$$\frac{\Delta i}{Imax} \times 100\ \% = \quad (7)$$

Large Neutral Current (% of Transformer Load Current)

To find the Neutral Current TR (% of Transformer Load Current) you can use the formula:

$$\frac{Netral\ current}{Average\ current\ of\ Phasa} \times 100\ \% = \quad (8)$$

To find the average current using the formula:

$$\frac{(R\ current + S\ current + T\ current)}{3} = \quad (9)$$

TR Current Loading (% Against KHA Outlet)

To find the TR Current Loading (% Against KHA Outlet) can use the formula:

$$\frac{Highest\ Current\ in\ the\ Department\ (Master\ Load)}{KHA\ Cable\ at\ Substation} \times 100\ \% \quad (10)$$

Determining the Measurement of Insulation Resistance

There is also to find out the minimum price standard of measuring the insulation resistance of an equipment can be calculated using the approach formula:

$$R = \frac{1000\ x\ U}{Q}\ x\ U\ x\ 2{,}5 \quad (11)$$

Captions :

R = Minimal solitary confinement; U = Working voltage. ; Q = Voltage insulation tester.
1000 = Fixed number.; 2,5 = Safety Factor (if new).

Note : Safety factor (2.5), when the working voltage is 400 V.

III. RESULTS AND DISCUSSION

3.1. PHB-TR G. 248 T PT PLN (PERSERO) UP3 PADANG Measurement Results

The research began on Wednesday, March 13, 2024 at noon, from 11.24 WIB to 12.11 WIB. The measurements carried out are supervised and directed directly by the field supervisor of PT PLN (Persero) UP3 Padang. The measurement data obtained can be seen from several types of measurements, namely as follows:

TABLE VIII
Phase Voltage Data - Phasa PHB-TR at G. 248 T PT PLN (Persero) UP3 Padang

No.	Phase	Phase Voltage - PHB Phase TR(V)
1.	R - S	402 V
2.	R - T	408 V
3.	S - T	403 V

TABLE IX
PHB-TR Phase - Neutral Voltage Data at G. 248 T PT PLN (Persero) UP3 Padang

No.	Phase	Phase Voltage - Neutral PHB-TR (V)
1.	R - N	234 V
2.	S - N	230 V
3.	T - N	233 V

TABLE X
Department Load Current Data on PHB-TR Load Usage Results

No.	Phase	Main Load (A)	Department load I (A)	Department load II (A)
1.	R	72 A	3,0 A	64, 8 A
2.	S	112,9 A	32,4 A	76,9 A
3.	T	103 A	7,3 A	96,7 A
4.	N	51,3 A	26,5 A	29,0 A

3.2. Calculation of power on each department loading

By using data obtained from PHB-TR measurements at the location of G. 248 T PT PLN (PERSERO) UP3 PADANG, we can calculate how much the power capacity of each department and transformer loading using measurement data.

1. Department Loading Power I
   Phase Load Power R = (IR x VR-N) = 3,0 A x 234 V = 702 VA
   Phase Load Power S = (IS x VS-N) = 32,4 A x 230 V = 7.452 VA
   Phase Load Power T = (IT x VT-N) = 7,3 A x 233 V = 1.700,9 VA
   Total Department Load Power I = 702 VA + 7.452 VA + 1.700,9 VA = 9.854,9 VA ➔ 9,8549 kVA
2. Department Loading Power II
   Phase Load Power R = (IR x VR-N) = 64,8 A x 234 V = 1.5163,2 VA
   Phase Load Power S = (IS x VS-N) = 76,9 A x 230 V = 1.7687 VA
   Phase Load Power T = (IT x VT-N) = 96,7 A x 233 V = 2.2531,1 VA
   Total Department Load Power II = 1.5163,2 VA + 17.687 VA + 2.2531,1 VA = 5.5381,3 VA ➔ 55,3813 kVA

Total Department Load = Department I + Department II = 9.854,9 VA + 55.381,3 VA = 65.236,2 VA ➔ 65,2362 kVA

We can calculate the load results of each previous department, according to the percentage of Transformer loading: % Load at Department I $= \frac{kVA\ Total\ load\ at\ department\ I}{kVA\ Transformer} \times 100\% = \frac{9,8549\ kVA}{160\ kVA} \times 100\% = 6,1\ \%$

% Load at Department II $= \frac{kVA\ Total\ load\ at\ department\ II}{kVA\ Transformer} \times 100\% = \frac{55,3813\ kVA}{160\ kVA} \times 100\% = 34,6\ \%$

Total Department $= \frac{kVA\ Total\ load\ at\ department\ I+II}{kVA\ Transformer} \times 100\% = \frac{9,8549\ kVA + 55,3813\ kVA}{160\ kVA} \times 100\% = 40,7\ \%$

3.3. Analysis of Calculation Results on Each Department Charge

The comparison of the total load power of department I and department II is 9.8549 kVA and 55.3813 kVA. We can see that, the amount of power usage in department II is influenced by the number of customers and electronic use at 11.24 WIB to 12.11 WIB. From the total results of transformer loading percentage, majors I and majors II were obtained at 40.7%, which included the criteria (Good) in accordance with the health index in Table 5 with a value of < 60% of the transforming power capacity of 160 kVA.

3.4. Imbalance of Inter-Phase Currents per Department G. 248 T

1. Department I
   I_{max} = 112,9 A
   I_{min} = 72 A
   Δi = 40,9 A
   % Department imbalance load I $= \frac{\Delta i}{Imax} \times 100\% = \frac{40,9}{112,9} \times 100\% = 0,3622 \times 100\ \% = 36,22\ \%$
2. Department II
   I_{max} = 96,7 A
   I_{min} = 64,8 A
   Δi = 31,9 A
   % Department imbalance load II $= \frac{\Delta i}{Imax} \times 100\% = \frac{31,9\ A}{96,7\ A}\ x\ 100\ \% = 0,3298\ A = 32,98\ \%$

3.5. Analysis of Inter-Phase Current Imbalance per Department G. 248 T

The results of the calculation of current imbalances between phases per department can be compared with Table 5, Department I 36.22% (Poor) and Department II 32.98% (Poor). This bad category is in accordance with the results of the health index which is more than ≥ 25%.

3.6. Calculating the Amount of Neutral Current (% of Transformer Load Current

Average current $= \frac{72+112,9+103}{3} = 95,96$ A

$$\frac{Netral\ current}{Average\ current\ of\ Phase} \times 100\ \% = \frac{51,3\ A}{95,96\ A} \times 100\ \% = 53,46\ \%$$

3.7. The analysis calculates the amount of neutral current (% to transformer load current

The result of the TR Neutral Current (% Against Transformer Load Current) has a value of ≥ 20% according to the results obtained, which is 53.46% (Bad) according to the health index in Table 5 as a foundation. The amount of current value obtained is also due to the load imbalance between phases, a large neutral current can produce power losses (losses).

3.8. TR Current Loading (% Against KHA Outlet)

The cable used on G.248 T PT. PLN (Persero) UP3 Padang uses a 4x70 mm2 cable which we can see in Table 9 that the KHA used in the 4x70 mm2 type cable is 207 A.

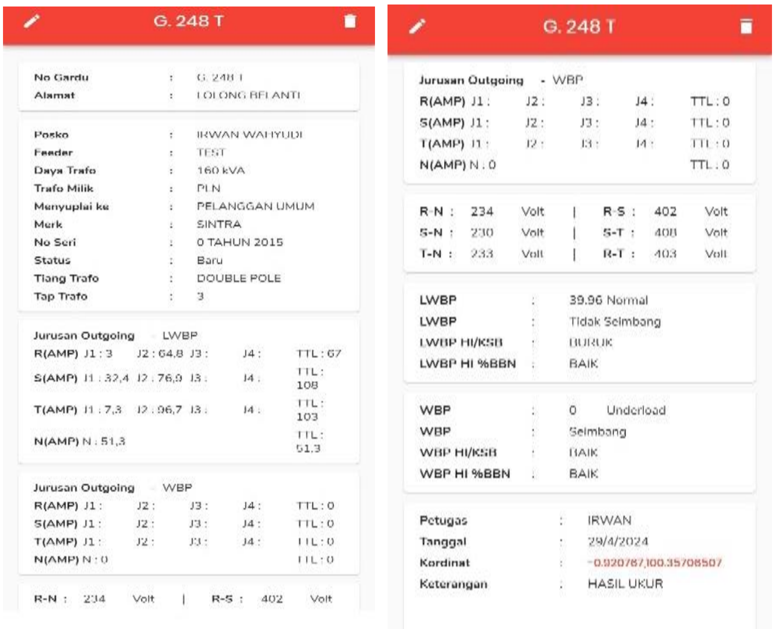
$$\frac{112,9\ A}{207\ A} \times 100\ \% = 54,54\ \%$$

3.9. TR Current Loading Analysis (% Against KHA Outlet)

The result obtained was 54.54% (Good) according to the health index in table 5 of the load taken for TR Current Loading (% Against KHA Outlet) which is the largest load between phases.

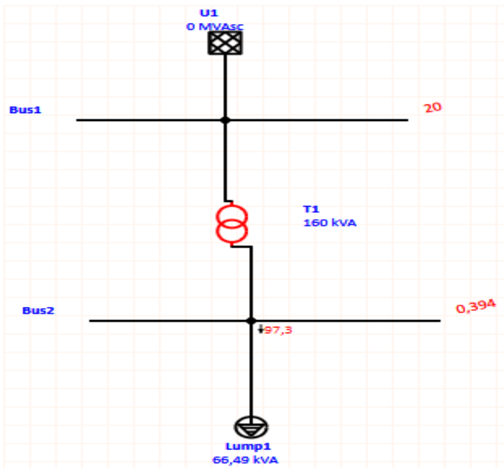
3.10. Modeling and Testing on G.248 T

1. Application of Monitoring Distribution Substation at G.248 T
   In Figure 3. After taking measurements at G. 248 T and testing using this application, the substation data that we have entered or input will appear. The LWBP obtained is 39.96% (Normal) while the transforming power is 160 kVA, it can be concluded that the load is not balanced. We can see the coordinates of the measurement using Google Maps in Figure 3. which is red with the condition that the coordinate points have been done (according to the field) before using this application



FIGURES 3. Results of Monitoring Measurement of Distribution Substation in G. 248 T

2. G.248 T simulation using ETAP application
   This simulation was carried out according to the measurement conditions in G. 248 T, in order to be able to compare the measurement results in the field with ETAP software and look for losses.



FIGURES 4. ETAP Test Simulation at G.248 T

ETAP simulation in Figure 4. according to the place of research conducted with a primary voltage of 20 kV, transformer power of 160 kVA, secondary voltage of 0.394 kV (according to ETAP simulation), and a total load of 66.49 kVA (according to ETAP simulation). Based on measurements made (according to field measurements), the secondary voltage produced is 400 V or 0.4 kV and the total load is 65.2362 kVA (according to the calculation obtained). This is because in the ETAP simulation, ETAP considers that all conditions are in ideal condition, both in terms of cable connections, grounding, and other components at the substation are considered in good or perfect condition.

Project:		ETAP		Page:	1
Location:		19.0.1C		Date:	30-04-2024
Contract:				SN:	
Engineer:		Study Case:	ULF	Revision:	Base
Filename:	Irwan etap			Config.:	Normal

Branch Losses Summary Report

CKT / Branch		From-To Bus Flow		To-From Bus Flow		Losses		% Bus Voltage		Vd % Drop in Vmag	Amperes in Buried Winding
ID	Phase	MW	Mvar	MW	Mvar	kW	kvar	From	To		
T1	A	0.018	0.008	-0.017	-0.011	0.7	-2.3	100.0	98.6	1.4	0
	B	0.023	0.009	-0.020	-0.007	2.5	2.4	100.0	98.7	1.3	0
	C	0.020	0.013	-0.022	-0.011	-2.4	1.6	100.0	98.3	1.7	0
						0.8	1.7				

FIGURES 5. Loses G. 248 T using ETAP

Transformer load shrinkage in Figures 5 is 0.8 kW per hour (Hour),

a. In 1 day (24 hours), transformer load shrinkage is as follows:
   0, 8 kW x 24 Hours = 19,2 kWH
b. With 1 month / 30 days (720 hours), transformer load shrinkage is as much as:
   19,2 kWH x 30 = 576 kWH atau 0,8 kW x 720 H = 576 kWH
c. In 1 year / 12 months (8640 hours), transformer load shrinkage is as follows:
   576 kWH x 12 = 6.912 kWH atau 0,8 kW x 8.640 H = 6.912 kWH

3.11. NH Fuse Current Calculation

Transformer capacity : 160 kVA
Voltage ratio: 20 kV/231 V – 400 V
Number of majors in PHB-TR: 4 (2 majors used)

1. In $= \frac{Transformer\ capacity\ (Volt.Ampere)}{\sqrt{3}\ x\ Phase{-}phase\ voltage\ (volt)} = \frac{160.000\ VA}{\sqrt{3}\ \ x\ \ 400\ V} = \frac{160.000\ VA}{692{,}82\ V} =$ 230,94 A
2. The Current of Each Department $= \frac{In\ (Ampere)}{\sum Department\ at\ PHB{-}TR} = \frac{230{,}94\ A}{2} =$ 115,47 A
3. KHA NH Fuse selected = The Current of Each Department x 0,9 = 115,47 A x 0,9 = 103, 923 A

3.12. Analysis of NH Fuse Current Calculation Results

On NH Fuse installed in 2 departments PHB-TR G.248 T PT. PLN (Persero) UP3 Padang, NH Fuse found rating values of 160 A, 250 A, and 300 A. The amount of NH Fuse 160 A installed all in department I due to the limited supply of NH Fuse available, so NH Fuse 160 A was used with larger spare for NH Fuse major I. In the results of measuring the current load of department I, the largest current value is 32.4 A in the S phase, of course, the NH Fuse in the S phase should be able to use NH Fuse with a rating value close to the magnitude of the current, such as NH Fuse 50 A or > 50A. If there is an additional load / addition of new customers, of course, the department current load increases with the rating distance closer to the NH fuse 50 A rating which allows short, so the installation of NH Fuse with a rating that is somewhat much greater than the value of the department load to avoid interference with the short current.

3.13. Calculating Cable Insulation Resistance

1. Q = 500 V
   R = $\frac{1000\ x\ 400}{500}$ x 400 x 2,5 = 800 x 400 x 2,5 = 800.000 Ω ➔ 0,8 M Ω
2. Q = 1.000 Volt
   R = $\frac{1000\ x\ 400}{1.000}$ x 400 x 2,5 = 160.000 x 2,5 = 400.000 Ω ➔ 0,4 M Ω
3. Q = 2.500 Volt
   R = $\frac{1000\ x\ 400}{2.500}$ x 400 x 2,5 = 64.000 x 2,5 = 160.000 Ω ➔ 0,16 M Ω
4. Q = 5.000
   R = $\frac{1000\ x\ 400}{5.000}$ x 400 x 2,5 = 80.000 Ω ➔ 0,08 M Ω

3.14. Analysis Calculating the Calculation of Isolation Resistance

From the results that have been obtained with the same working voltage, namely 400 Volts and different insulation tester (Q) voltages of 500 Volts, 1,000 Volts, 2,500 Volts, and 5,000 Volts in accordance with the measurement voltage selector on the insulation tester. The different voltage insulation testers are carried out as tests or tests to find out the value of good results and close to 1.0 M Ω.

IV. CONCLUSION

The magnitude of the result of inter-phase current imbalance in Department I 36.22% (Poor) and Department II 32.98% (Poor), so it is necessary to move customers from the highest single-phase load to the lowest one-phase load. We can see in table 4.3 Department I of the large S phase current of 32.4 A which has a greater current than the R phase current of 3.0 A and the T phase current of 7.3 A with a much different difference. To make load balancing efforts to match the health index criteria that are suitable for use, some customers in the S phase are transferred to the R and T phases.

The selection of components must be adjusted to the electrical load and customer needs, also understanding load patterns and energy usage characteristics helps to select components that can be optimized to provide maximum protection on PHB-TR G. 248 T PT PLN (PERSERO) UP3 PADANG. As for the way to maintain the quality of PHB-TR, of course, Preventive Maintenance is carried out both Daily, Weekly, and Monthly according to functional to ensure reliability so that components that are damaged or can no longer be used faster to process also do not hamper and interfere with customer comfort when operating.

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