[1]Pawenary

[2]Shabrina Fajriyanti

Performance Analysis Project of OCR and DGR Protection Settings on Tristex Feeder of New Substation Using Digsilent Power Factory Software

Journal of Electrical Systems

***Abstract:* -** Increasing the reliability of the electricity system is very important in maintaining a stable and guaranteed electricity supply. One important factor in the electrical protection system is the setting of over current relay (OCR) and directional ground relay (DGR) settings. This study aims to analyze and evaluate the performance of the OCR and DGR protection settings on the New Pandaan Tristex Substation using DIgSILENT software. The method used in this research is modeling and simulation using DIgSILENT software. Relevant data and electrical system parameters are obtained from reliable sources. OCR and DGR protection settings are evaluated by considering protection needs through simulation analysis of fault conditions and normal operation. Tristex feeder is one of the feeder in GI New Pandaan with a total length of 2.415 km. The calculation results for the OCR setting on the incoming 20 kV side obtained for the TMS value = 0.20 while for the OCR setting on the 20 kV feeder side obtained the TMS value = 0.15. Then for the DGR setting on the incoming 20 kV side, the TMS value = 0.26 is obtained, while for the DGR setting on the 20 kV feeder side, the TMS value = 0.10 is obtained..

Keywords: Short Circuit; Protection; Over Current Relay; Directional Ground Relay

I. INTRODUCTION *(HEADING 1)*

The electric power system requires a network distribution system that can guarantee the reliability and continuity of distribution from the generator or substation to the consumer. Reliability of electrical energy supply is a satisfaction for consumers, so when a disturbance occurs that causes the process of distributing electrical energy to be hampered, it will be able to cause disappointment for consumers. Therefore, a protection system is needed that can prevent the occurrence of these disturbances. The protection system in the electric power system is very important because of its function as a safety against existing disturbances. In electric power systems, disturbances usually occur in the form of short circuits, overloads, overvoltages, etc. So that the protection system is expected to be able to protect equipment. So that the protection system is expected to be able to protect electrical equipment from damage due to abnormalities or disturbances that exist. In addition, protection or safety systems that are no less important have a function in protecting humans and other living things from electrical hazards.

One of the disturbances that often occurs is a short circuit, be it a three-phase short circuit, an inter phase short circuit, or a phase-to-ground short circuit. This disturbance greatly affects electricity distribution. One of the tools of the protection system is a relay whose function is to detect abnormalities or other abnormal conditions, which then give orders to the PMT to trip. The protection of the 20kV feeder at the substation must be set faster than the incoming 20kV protection, and the protection on the distribution network must be set faster than the 20kV extension protection. Therefore, a good relay setting is needed in accordance with the time agreement setting to protect electrical power equipment from a short circuit or overload. Before an actual fault occurs, it is important to know the amount of short-circuit current that can occur in the electrical system. This is usually used in the planning of electrical power equipment, such as setting PMT specifications, selecting appropriate conductors, determining the thermal capacity of current transformers, and so on. Then it is also needed for the operation of determining the magnitude of the short circuit fault at each point of the network, including the calculation of the protection relay settings. Before implementing this protection system, calculations and analysis are needed to determine the settings of the relay so that it can work properly in the event of a disturbance and act as safety protection according to its function, thus ensuring the stability of the distribution of electricity and avoiding damage to other equipment [1].

Novia et al. [2] in their research aim to analyze the relay protection system when a disturbance occurs at a distance of 7.210 km from the power line. The short-circuit current in the power line reaches 2,552.2459 A when short-

[1]Institut Teknologi PLN, Jakarta, Indonesia

[2]Institut Teknologi PLN, Jakarta, Indonesia

circuited. For TMS at the incoming, OCR is worth 1.1157 seconds, while DGR is worth 0.3985 seconds. On the feeder side, the TMS on OCR is 0.1214 seconds, while the DGR is 0.1825 seconds. Sukamdi et al. [3] explained in their research that the repeater often experiences disturbances that result in protection coordination failures, so the calculation of new relay settings is carried out, namely OCR and DGR, which are then simulated with ETAP software.

Furqon et al. [4] explained in their research that in order for substation protection to work properly and the ground phase current to be less than the nominal current, it is necessary to install a grounding cable on the ground. At Polehan Substation, the grounding system has a resistance of 500 ohms with a DGR (Ground Fault Detection) setting value of 2 A. Then, because the results of the analysis show that the relay setting is not good, the grounding system is not good. Then, because the analysis results show that the relay setting at the substation is longer than the substation, it can result in relay protection at the substation not being able to back up when a phase-to-ground fault occurs. Therefore, it is important to adjust the settings between the substation and the substation. Arka has in his research the aim of developing an effective protection system against phase-to-ground faults by using DGR installation. So by installing DGR as well as using GPT and ZCT, it is hoped that phase-to-ground faults can be properly and efficiently detected and isolated by the protection system. So that the distribution system and electric equipment can be protected from damage due to phase-to-ground faults.

Pahiyanti & Sukmajati [6] in their research explain how to adjust the relay settings when a single phase-ground or phase-phase fault occurs and also check the relay working time when a fault occurs. The results obtained show that the value of the one-phase ground fault current is influenced by the size of the zero-sequence impedance. Setiajie et al. [7] explained in their research that in the distribution of electricity, to minimize or reduce interference, a protection system is needed. The protection tools used are OCR and GFR, with the results obtained by setting the incoming side OCR TMS value to 0.258 and the outgoing side TMS value to 0.224. For the GFR setting on the incoming side, the TMS value is 0.423, and on the outgoing side, the TMS value is 0.287. So from these results, it appears that the installed settings are in good condition. Hajar & Mercury [8] explained in their research the use of differential relay settings that affect the reliability of the plant with quantitative methods. The results obtained show that the relay is in good condition with a relay setting of 0.1804 A. Thaha et al. [9] explained in their research the analysis of OCR and GFR settings at GI Sanga-sanga using the DifSILENT Power Factory 15.1.7 application. This coordination is carried out to improve the quality of service to customers, minimize outages, reduce losses, and improve the closing time so that one 20 kV transformer bay is built.

Soewono & Noprianti [10] explained in their research the improvement of protection performance using ETAP due to frequent short circuit faults. The results obtained indicate that the relay should not operate above 1100 A (maximum) and below 98 A (minimum) because if it works outside the load range, the coordination time will not meet the manual standards. Togatorop [1] explains in his research that because of the frequent occurrence of phase-to-phase short circuit patterns and single-phase ground fault patterns, if this disturbance or abnormality is allowed to occur, it can damage the equipment in the substation. So it is necessary to set an overcurrent relay or a good ground fault relay; the relay must be set at a fixed time in order to overcome potential disturbances that may occur. it can damage the equipment in the substation. So it is necessary to set an overcurrent relay or a good ground fault relay; the relay must be set at a fixed time in order to overcome potential disturbances that may occur.The introduction section of your paper should include the necessary background information, including an ade-quate review of earlier findings and the justification for conducting this study.

II. LITERATURE REVIEW

In this study, to carry out the data analysis method, there were several stages, namely:

Impedance

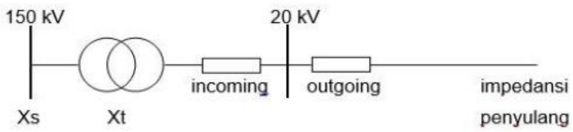

Figure 1. Sketch of a Medium Voltage Feeder

a. Source Impedance

Since the calculated impedance is the impedance on the 150kV and 20kV sides, the impedance calculation on the 150kV side requires MVAsc data.

$$MVA = \sqrt{3} \times \mathrm{Kv150} \times \mathrm{Isc} (1)$$

After getting MVAsc, we can then calculate Zsc (150kV) by means of:

$$\mathrm{Zsc(150kV)} = \mathrm{kVprimer}^2 \,/\, \mathrm{Zsc(150kV)} \quad (2)$$

Then the Zsc (150kV) value is converted to the 20kV side using the formula:

$$\mathrm{Zsc(20kV)} = \frac{kV_{sekunder}{}^2}{kV_{primer}{}^2} \times \mathrm{Zsc(150kV)} \quad (3)$$

a. Power Transformer Reactance

To calculate the value of positive sequence reactance, negative sequence reactance, and zero sequence reactance at 100%, namely by formula:

$$\mathrm{XT\ (at100\%)} = \mathrm{kV(sisi\ 20kV)}^2 \,/\, \mathrm{MVAtrafo} \quad (4)$$

Reactance value of power transformer:

1. Positive sequence and negative sequence reactance

$$(X_{T1}=X_{T2})$$

The amount of this reactance depends on the capacity of the power transformer, where the positive sequence reactance is the same as the negative sequence reactance (XT1 = XT2). The amount of positive and negative sequence reactance is found on the name plate of the power transformer.

$$\mathrm{XT1} = \mathrm{XT2} = \mathrm{XT(\%)} \times \mathrm{XT}(\Omega) \quad (5)$$

1. Zero-sequence reactance (X_{T0})

The amount of zero-sequence reactance is obtained from the data on the power transformer by looking at the power transformer for the delta coil as the third coil, where:

a. The delta coil capacitance (d) is equal to the Y capacitance for power transformers with Dyn coil connections, so XT0 = XT1.

b. For power transformers that have Ydyn coil connections, the delta coil capacitance (d) is one-third of the Y coil capacitance (the capacitance used to transfer power while the delta coil remains on the power transformer but is not removed except for the ground of one delta terminal), hence:

$$\mathrm{XT0} = 3 \times \mathrm{XT1} \quad (6)$$

c. For power transformers that have Yyn coils and no delta coils in them, the size of XT0 is 9 to 14x XT1.

1. Line Impedance

The measured impedance of the feeder is based on the measured impedance per kilometer (ohm/km) of the feeder, the value of which is determined by the type of conductor, the length of the SUTM or SKTM network, and the cross-sectional area. Based on SPLN 64:1985, if the 20 kV conductor uses 150 mm2 SUTM, the feeder resistance can be calculated using the formula :

1. Positive and negative sequence impedance

$$\mathrm{Z1} = \mathrm{Z2} = \mathrm{Network\ Length\ (km)} \times \mathrm{Z1}\ (\Omega) \quad (7)$$

2. Zero-sequence impedance

$$\mathrm{Z0} = \mathrm{Network\ Length\ (km)} \times \mathrm{Z0}(\Omega) \quad (8)$$

a. Equivalent Impedance

From the source to the point of interference, an impedance is formed that is connected in series so that for this equivalent impedance, the value of the negative, positive, and zero equivalent impedances from the point of interference to the source can be calculated. But this calculation can directly use the method by summing the impedances z_{1eq} and z_{2eq}, while the calculation of z_{0eq} starts from the point of interference to the point of interference of the power transformer whose neutral point is grounded. However, the transformer winding circuit must be known to calculate the z_{0eq} impedance.

So to calculate the network equivalent impedance of the feeder, you can calculate it using the formula:

- Positive and negative sequence (Z1=Z2)

$$\mathrm{Z1eki} = \mathrm{Z2eki} = \mathrm{Zsc(20kV)} + \mathrm{XT1} + \mathrm{Z1(feeder)} \quad (9)$$

- Zero sequence (Z0)

$$\mathrm{Z0eki} = \mathrm{XT0} + \mathrm{3RNGR} + \mathrm{Z0(feeder)} \quad (10)$$

III. METHOD

1 Short Circuit Current

a. 3 Phase Short Circuit Current

The faults that generally exist in electric power networks which can be caused by three phases connected to a tree or wires from a kite filament are usually called three phase short circuit faults. The following is the formula for calculating 3-phase faults:

$$\mathrm{Isc3ph} = \mathrm{Vph} / \mathrm{Z1eki} \quad (11)$$

b. 2 Phase Short Circuit Current

Two-phase short circuit is a short circuit fault that occurs between two phases without being connected to ground. Here is the formula for calculating 2-phase faults:

$$\mathrm{Isc2ph} = \mathrm{Vph} / \mathrm{2Z1eki} \quad (12)$$

c. 1 Phase-Ground Short Circuit Fault

This interference occurs when the conductor is hit by a tree or a grounded cable. If the conductor is not connected to ground, then the fault (phase to earth) will not occur.

$$\mathrm{Isc1ph} = \mathrm{3Vph}/(\mathrm{Z1eki} + \mathrm{Z2eki} + \mathrm{Z0eki}) \quad (13)$$

2 OCR and DGR Relay Settings

1. Settings OCR

Feeders are used on the secondary and primary sides of the power transformer to calculate the OCR setting current using the following formula:

$$\mathrm{Iset(primary)} = 1{,}05 \times \mathrm{Inominal\ trafo} \quad (14)$$

For OCR relay setting values according to the provisions of the British standard, namely:

- *Inverse relays* using a setting that is 1.05 to 1.3 x I (load)

- *Definite relays* using a setting that is 1.25 to 1.3 x I (load)

The nominal current on the primary and secondary side of the power transformer is:

$$\mathrm{In} = \mathrm{kVAtrafo} / \mathrm{kVtrafo}\sqrt{3} \quad (15)$$

This value is the primary setting current, while to calculate the secondary setting using the CT (current transformer) ratio in the feeder of the primary and secondary parts of the power transformer.

$$\mathrm{Iset(secondary)} = \mathrm{Iset(primary)} \times 1/\mathrm{Rasio\ CT} \quad (16)$$

Next, a Time Multiple Setting (TMS) calculation is performed, which is to set the TMS value using the calculation of the previous short circuit current. So to calculate the TMS value you can use the formula:

$$\mathrm{TMS} = \mathrm{t}((\mathrm{Isc3ph}/\mathrm{Iset(primer)}\alpha - 1)/\beta \quad (17)$$

Table1. α and β Factors According to Curve Type

Curve Type	α	B
Definite Time (DT)	-	-
Standard Inverse (SI)	0.02	0.14
Very Inverse (VI)	1	13,2
Extremely Inverse (EI)	2	80
Long Time Inverse (LTI)	1	120

- Feeder 20 kV

The TMS OCR relay setting on the 20 kV feeder side of the power transformer uses a 3 phase short circuit fault current reference of 0% of the feeder length. The lowest working time set is t = 0.3 seconds.

- Incoming20 kV

The TMS OCR relay setting on the 20 kV feeder side of the power transformer uses a 3 phase short circuit fault current reference of 0% of the feeder length. For the working time of the relay used, it is taken from the feeder side and the incoming side, namely 0.3 seconds and 0.4 seconds. So later the working time of the relay (t) used on the incoming side is 0.7 seconds.

1. Settings DGR

Feeder 20 kV

$$\mathrm{Iset(primary)} \ = \ 10\%\mathrm{x}(\mathrm{Isc1ph\ terkecil}) \quad (18)$$

Incoming 20 kV

Because it is a backup for the relay in the 20 kV feeder, the adjustment of the abnormal current (disturbance) on the incoming 20 kV must be more sensitive.

$$\mathrm{Iset(primer)} \ = \ 8\% \text{ x } (\mathrm{Isc1ph\ terkecil}) \quad (19)$$

Then to calculate the setting current on the secondary use formula (16).

For the calculation of Time Multiple Setting (TMS) on DGR which is to set the TMS value using the calculation of the previous short circuit current. For the working time of the relay (t) on the feeder side it is set to 0.3 seconds while on the incoming side it is set to 0.7 seconds. So to calculate the TMS value you can use formula (17).

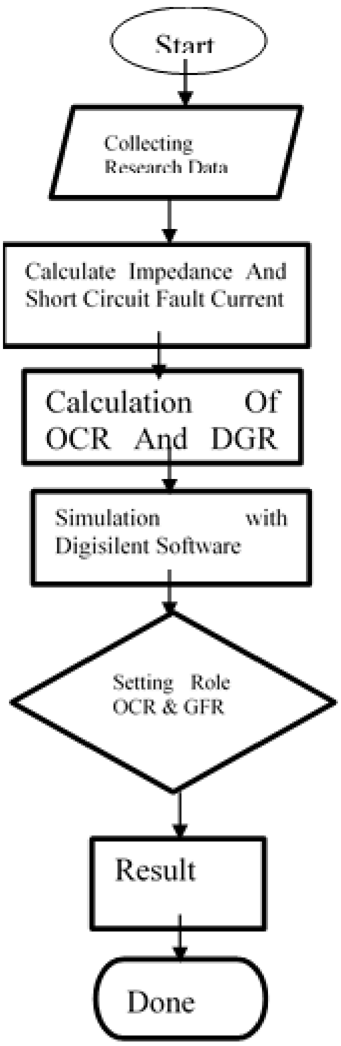

Figure 2. Research Flowchart

Material

Table 1. New Pandaan GI transformer data

Number	Transformer 1
Brand	SCHNEIDER
Capacity	60MVA
Primary Voltage	150 kV
Secondary Voltage	20 kV
Impedance	11.62 %
Secondary Current	1732 A
Transformer Winding	YNyn0+d
RNGR	40 Ohms
Cooler	ONAN/ONAF

Table 2. Tristex feeder data

Feeder Name	Tristex
Feeder Type	AAAC 3 x 150 mm2
Feeder Length	2,415 kms
Z1 = Z2	(0.2162 + j0.3305) Ω/km
Z0	(0.3631 + j1.6180) Ω/km

IV. RESULT

Calculation of Power Transformer Data

Short circuit data obtained from P2B for GI New Pandaan on the primary side bus (150kV) then the 150kV side source impedance is:

$$MVAsc = \sqrt{3}x\ 150kV\ x\ 15{,}91kA = 4133{,}54\ MVA$$

After getting the MVASC, Zsc can be searched(150kV)that is:

$$Zsc(150kV) = (150kV)2\ /\ 4133{,}54\ MVA = 5{,}44\ \Omega$$

Then to get the impedance on the secondary side it can be calculated using the formula:

$$Zsc(20kV) = (20kV)^2\ /\ (150kV)^2\ x\ 5{,}44\ \Omega = 0{,}10\ \Omega$$

Calculation of Power Transformer Reactance

a. Transformer Reactance at 100%

$$XT(pada\ 100\%) = (20kV)2\ /\ 60\ MVA = 6{,}667\ \Omega$$

b. Positive and Negative Sequence Transformer Reactance

$XT1 = 11{,}62\%\ x\ 6{,}667\ \Omega = 0{,}77\ \Omega$

c. Zero Sequence Transformer Reactance

In calculating the zero sequence reactance of this power transformer, since the transformer has a YNyn0+d winding connection that supplies the Basil Feeder, the value X_{T0} is three times that of X_{T1}.

$$XT0 = 3\ x\ 0{,}77\ \Omega = 2{,}31\ \Omega$$

Feeder Impedance Calculation

a. Impedance of positive and negative sequence (Z_1=Z_2)

$$Z1 = Z2 = 2{,}415km\ x\ (0{,}2162 + j0{,}3305)\Omega/km\ Z1 = Z2 = (0{,}52 + j0{,}80)\Omega/km$$

b. Zero sequence impedance (Z_0)

$$Z0 = 2{,}415\ km\ x\ (0{,}3631 + j1{,}6180)\ \Omega/km$$

$$Z0 = (0{,}88 + j3{,}91)\ \Omega$$

Equivalent Impedance Calculation

a. Impedance of positive and negative sequence

$Z1eki = Z2eki = j0.10 + j0.77 + Z1(feeder)$

$$Z1eki = Z2eki = j0.87 + Z1(feeder)$$

b. Zero sequence impedance

$Z0eki = j2{,}31 + (3x40) + Z0(feeder)$

$$Z0eki = 120 + j2{,}31 + Z0(feeder)$$

3 Phase Short Circuit Current Calculation

$$Isc3ph = 20000\sqrt{3}\ /Z1eki = 11547\ /Z1eki$$

Table 3. 3 Phase Short Circuit Current

Feeder Length (%)	3 Phase Short Circuit Current
1%	13151.27 A
25%	10712.81 A

50%	8907.38 A
75%	7592.44 A
100%	6601.74

2 Phase Short Circuit Current Calculation

$$Isc2ph = 20000 / Z1ek$$

Table 4. Calculation of 2 Phase Short Circuit Current

Feeder Length (%)	2 Phase Short Circuit Current
0%	11363.45 A
25%	9277.57 A
50%	7714.02 A
75%	6575.25 A
100%	5717.27 A

Calculation of Single Phase-Ground Short Circuit Current

$$Isc1ph = 34641{,}016 / (2 \, x \, Z1eki + Z0eki)$$

Table 5. Calculation of 1 Phase-Ground Short Circuit Current

Feeder Length (%)	Short Circuit Current 1 Phase-Ground
0%	288.46 A
25%	287.23 A
50%	285.93 A
75%	284.61 A
100%	283.26 A

From the results of the calculation above, namely the calculation of impedance and short circuit current, it can be seen that the magnitude of the short circuit fault current is affected by the impedance and distance of the feeder. Where the farther the feeder distance, the smaller the short circuit current, but the greater the impedance. Meanwhile, the shorter the feeder distance and the smaller the impedance, the greater the short circuit current. Then when viewed from the disturbance of the phases, the largest fault current is the 3-phase short circuit current.

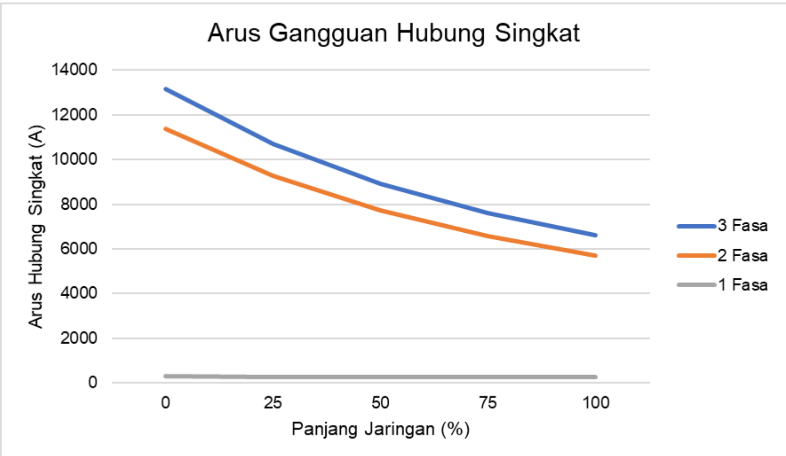

Figure 3. Short Circuit Fault Current Curve

OCR and DGR Relay Settings

1. Feeder Side 20 kV

a. Settings OCR

$Iset(primary) = 1{,}05 \; x \; 410 \; A$

$$Iset(primary) = 430{,}5 \; A$$

The current value is the setting value on the primary side, while the value set for the relay is the secondary value. Therefore, it is calculated using the ratio of the current transformer installed in the feeder. The amount of current on the secondary side is:

$$Iset(sekunder) = 430{,}5 \; x \; (5/600)$$

$$Iset(sekunder) = 3{,}59 \; A$$

In determining the TMS setting on the OCR on the feeder side of the 20 kV power transformer, the fault current is chosen to be used as the basis for the setting. The selected fault current is the 3-phase short circuit fault current at 0% of the feeder length. The closest working time is set at t = 0.3 seconds.

$$\text{TMS} = \frac{0{,}3 \times \left(\left(\frac{13151{,}27\ A}{430{,}5\ A}\right)^{0{,}02} - 1\right)}{0{,}14}$$

$$\text{TMS} = 0{,}15$$

The working time of the relay can be calculated as follows:

$$t = \frac{0{,}14}{\left(\frac{13151{,}27\ A}{242{,}55\ A}\right)^{0{,}02} - 1} \times 0{,}15$$

$$t = 0{,}25 \text{ seconds}$$

a. Settings DGR

To accommodate the arc resistance, the ground fault current setting on the feeder is set to 10% of the smallest ground fault current.

$$I_{set(primer)} = 10\% \times 283{,}26 \text{ A}$$

$$I_{set(primer)} = 28{,}33 \text{ A}$$

$$I_{set(sekunder)} = 430{,}5 \text{ x } (5/600)$$

$$I_{set(sekunder)} = 0{,}24 \text{ A}$$

$$\text{TMS} = \frac{0{,}3 \times \left(\left(\frac{288{,}46\ A}{28{,}33\ A}\right)^{0{,}02} - 1\right)}{0{,}14}$$

$$\text{TMS} = 0{,}10$$

The working time of the relay can be calculated as follows:

$$t = \frac{0{,}14}{\left(\frac{288{,}46\ A}{28{,}33\ A}\right)^{0{,}02} - 1} \times 0{,}10$$

$$t = 0{,}29 \text{ seconds}$$

Side incoming 20 kV

a. Settings OCR

$$I_{set(primer)} = 1{,}05 \times 1732 \text{ A}$$

$$I_{set(primer)} = 1818{,}6 \text{ A}$$

$$I_{set(sekunder)} = 1818{,}6 \times (5/600)$$

$$I_{set(sekunder)} = 15{,}16 \text{ A}$$

$$\text{TMS} = \frac{0{,}7 \times \left(\left(\frac{13151{,}27\ \text{A}}{1818{,}6\ \text{A}}\right)^{0{,}02} - 1\right)}{0{,}14}$$

$$\text{TMS} = 0{,}20$$

$$t = \frac{0{,}14}{\left(\frac{13272{,}41\ \text{A}}{1818{,}6\ \text{A}}\right)^{0{,}02} - 1} \times 0{,}20$$

$$t = 0{,}69 \text{ seconds}$$

b. Settings DGR

On the incoming 20 kV side, the relay settings must be more sensitive. Because it serves as a backup for the relay in the 20 kV feeder. The setting is set at 8% of the smallest earth fault current.

$$I_{set(primer)} = 8\% \times 283{,}26 \text{ A}$$

$$I_{set(primer)} = 22{,}66 \text{ A}$$

$$I_{set(sekunder)} = 22{,}66 \times (5/600)$$

$$I_{set(sekunder)} = 0{,}19 \text{ A}$$

$$\text{TMS} = \frac{t \times \left(\left(\frac{Isc_{1\phi}}{I_{set\ (primer)}}\right)^{0{,}02} - 1\right)}{0{,}14}$$

$$\text{TMS} = 0{,}26$$

$$t = \frac{0{,}14}{\left(\frac{Isc_{1\phi}}{I_{set}}\right)^{0{,}02} - 1} \times \text{TMS}$$

$$t = 0{,}70 \text{ seconds}$$

Modeling Single Line Diagram on DIgSILENT

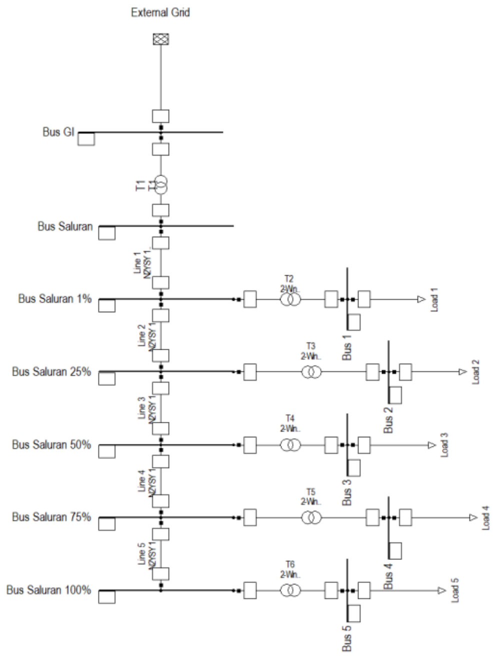

Figure 4. Tristex Feeder SLD

Table 6. Comparison of Interference Results

Bus Length(%)	3 Phase (A)		2 Phase (A)		1 Phase (A)	
	Calculation	Simulation	Calculation	Simulation	Calculation	Simulation
1	13151.27	14586.95	11363.45	12632,67	288.46	18337,62
25	10712,81	7220,366	9277.57	6253,021	287,23	14937,92
50	8907.38	13435.02	7714.02	11635.07	285.93	10472,37
75	7592.44	11450.68	6575,25	9916.58	284.61	7050,193
100	6601.74	9218,285	5717,27	7983,269	283,26	4859.57

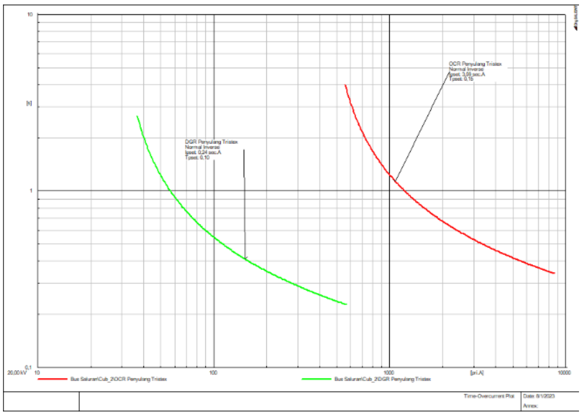

Figure 5. Short Circuit Fault Coordination Curve

Based on the coordination curve between the OCR and DGR relays above, it can be seen that the results obtained are good because there are no mutually exclusive curves. So when a phase-to-ground fault occurs, the OCR (red curve) will give a trip command to CB to disconnect, and so when there is a phase-to-ground fault, DGR will work first to trip over CB.

V. CONCLUSION

Based on the calculation of the short circuit current, it is found that the greatest fault current occurs in a three-7 phase fault, namely 13272.41 A, while the smallest fault current occurs in a single-phase fault of 270.03 A. Based on the calculation results for the OCR setting on the 20 kV incoming side, the TMS value = 0.20 is obtained, while for the OCR setting on the 20 kV feeder side, the TMS value is 0.15. Then for the DGR setting on the 20 kV incoming side, the TMS value = 0.26 is obtained, while for the DGR setting on the 20 kV feeder side, the TMS value is obtained = 0.10. Based on the results of the protection simulation that has been carried out, when a fault occurs, the relay will read the fault current and give a trip command to the CB to cut off the electricity.

ACKNOWLEDGMENT

Author thanks to Institut Teknologi PLN, Jakarta, Indonesia. The authors did not receive support from any organization for the submitted work

REFERENCES

[1] D. D. Togatorop, "Analisa Kinerja Setting Rele OCR dan GFR Penyulang Patraraya di Transformator 2 Gardu Induk Cerme," 2019.

[2] C. Novia, H. Tasmono, and R. S. Widagdo, "Analisa Setting Relay Pada Penyulang Simo Kwagean," Pros. Senakama, vol. 2, pp. 641–651, 2023.

[3] Sukamdi, R. A. Ananto, and R. H. Abi, "Analisis Koordinasi Pengaman Pada Jaringan Tegangan Menengah 20 kV Penyulang Wajak," ELPOSYS J. Sist. Kelistrikan, vol. 7, no. 1, pp. 25–29, 2020, doi: 10.33795/elposys.v7i1.94.

[4] S. Z. Furqon and B. M. B, "Analisis Pengaruh Pemasangan Grounding Kabel Tanah 20 kV di Gardu Hubung Sarangan PLN Rayon Malang Kota untuk Menurunkan Gangguan Penyulang Menggunakan E-Tap 12.6," J. Chem. Inf. Model., vol. 6, no. 1, pp. 27–36, 2017, [Online]. Available:http://www.riset.unisma.ac.id/index.php/jte/article/view/1650

[5] G. P. Arka, "Sistem Proteksi Gangguan Fasa Tanah Melalui Pemasangan Directional Ground Relay (DGR) Pada Penyulang 20 kV Sempidi Gi Kapal," J. Log., vol. 17, no. 3, pp. 130–135, 2017, [Online]. Available http://ojs.pnb.ac.id/index.php/LOGIC/article/view/601

[6] N. G. Pahiyanti and S. Sukmajati, "Proteksi Arus Lebih pada Penyulang Lenguh (SKTM) dan Penyulang Aum (SUTM)," J. Energi Kelistrikan, vol. 7, no. 2, pp. 144–149, 2015.

[7] P. Setiajie, Juningtyastuti, and S. Handoko, "Evaluasi Setting Relay Arus Lebih dan Setting Rela Gangguan Tanah Pada Gardu Induk Srondol," Transient, vol. 4, no. 2, pp. 237–243, 2015.

[8] Hajar and M. R. Mercury, "Analisa Setting Rele Differensial Pada Generator PT. PJB UBJ O & M PLTU Rembang," J. Ilm. SUTET, vol. 9, no. 1, pp. 1–15, 2019.

[9] S. Thaha, A. W. Indrawan, and Y. J. Pongkiding, "Analisis Sistem Koordinasi Proteksi Over Current Relay (OCR) Dan Ground Fault Relay (GFR) Tegangan 20 Kv Bay Trafo Pada Gardu Induk Sanga-Sanga Kalimantan Timur," J. Teknol. Elekterika, vol. 19, no. 2, pp. 116–122, 2022.

[10] S. Soewono and E. Noprianti, "Analysis of Over Current Relay and Ground Fault Relay Protection System in Sub-Station SP-2 Tanah Miring Using Relay Coordination with ETAP Based," Int. J. Inf. Syst. Comput. Sci., pp. 89–97, 2020.