Journal of Electrical Technology UMY (JET-UMY), Vol. 3, No. 2, June 2019
ISSN 2550-1186 e-ISSN 2580-6823

Study Of Over Current Relay Analysis On The Transformer To Minimize Error By Comparing Calculations With Etap Software 12.6

Fahmi ilhami[*1], Ramadoni Syahputra[1], Anna Nur Nazilah chanim[1], Kunnu Purwanto[2]

[1]Department of Electrical Engineering, Universitas Muhammadiyah Yogyakarta
Jl. Lingkar Selatan, Tamantirto, Kasihan, Yogyakarta, Indonesia

[2]Production on the Job Trainer and Competence Assessor, Petroleum Development Relay Protection
, Pertamina RU VI Balongan, Indramayu, Jawa Barat, Indonesia.

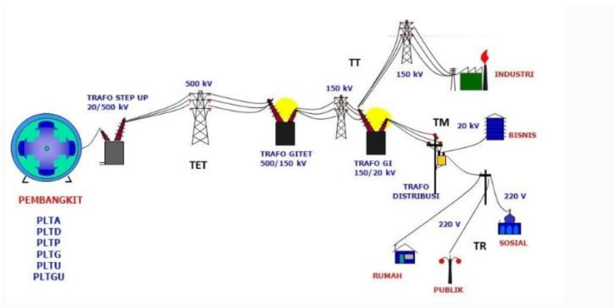
*Corresponding author, e-mail: fahmi9125@gmail.com

Abstract - *Electric power systems have substations or substations to distribute electricity from the generator to the load, in general ETAP 12.6 software is used to simulate its distribution so that there is no internal or external interference when in the field, of course according to the needs of consumers in the distribution there needs to be safety or protection good in accordance with the philosophy of protection sensitive, accurate, reliable, and economical, one of the important protections is Overcurrent Relay to detect short circuit interference both on the upstrem and downstrem sides so as not to damage all components in a system when remembered with the very component prices. expensive especially in transformer protection. For protection to work properly, it is necessary to have benchmarks with international standards such as IEE (Institute of Electrical and Electronics Engineers) or IEC (International Electrotechnical Commission). In this final project will be discussed Analysis of Over Current Relays (Ocr) Analysis of the Transformer to Minimize Damage by Comparing Manual Calculations with Etap 12.6 Software to find out the working simulations of the relays. Overcurrent Relay is used as an overcurrent protection relay that will pinpoint the PMT when the current exceeds the setting limit value.*

Keywords: *PMT, Overcurrent relay, ETAP 12.6*

I. Introduction

In this globalization era electricity is a part of the lives of almost all sectors of the field both academics such as universities or schools and practitioners such as factories and industrial housing all use electricity. This is caused because almost all the existing facilities such as projectors, sound systems or lights and so on require electricity to activate and use it.



In the processing of electricity itself from the generator to the consumer through several stages, namely from the generator then the voltage is increased by the step up transformer on the transmission network then the voltage is reduced

Manuscript received April 2020, revised May 2019

back on the distribution network with the stepdown transformer until we can use it such as watching TV or using a washing machine even for cooking In order to maximize the performance of the transformer, it is necessary to have experiments and estimates, such as using ETAP 12.6 software, that there will be no failures and losses in the field. but in reality processing electricity is not as easy as expected as many disturbances from several factors such as natural factors such as rain, tornado or the collapse of trees or electrical factors, namely overload, overcurrent that has ever experienced by PT. Pertamina RU VI Balongan Indramayu, West Java due to natural disruptions that result in short or short circuit. The cause of overcurrent in the network is caused by internal or electrical factors, namely excessive flow which will result in sparks to damage the system, to anticipate the need for protection coordination system.

In the protection system, there are several things that must be considered, such as the protection philosophy, namely reliability, speed, sensitivity and economy. The reliability of the protection system is highly demanded for the sustainability of electricity distribution. For this reason, coordination between support and protection is needed. One of the important protections in the transformer is Overcurrent Relay to secure the transformer and also the network system.

II. Literature Study

II.1 Literature review

Electric power is one of the basic needs at this time. Therefor it is necessary to have a protection system so that electricity can continue to be distributed even though there are some problems in some systems. From this analysis, we will get the value of overcurrent overlay protection (OCR) and transformer ground disturbance (GFR) over transformer protection settings and how the coordination of the OCR and GFR is shown in the graph. Based on these results it is very necessary to evaluate the relay settings because the MVA every year at the substation is not always the same [1]. The word PLTGU needs to be evaluated each year using ETAP 12.6 software. After being evaluated, the generator protection relay and generator transformer settings are still appropriate or appropriate for operation, except overcurrent relays, negative sequence relays and under frequency relays that change from the existing value [2].

Electricity in Central Java adheres to a direct grounding system along the network (solidly grounded common neutral), so that the current disruption occurs is very large, then the expansion or overloading of other feeders must consider the range of sensing of the safety equipment and coordinate between the safety of one another, coordination protection system plays a very important role to ensure the reliability of the electricity distribution system [3]. In a distribution system, there needs to be an evaluation in order to ensure that the system is working properly or not. Protection evaluation includes coordination between protective equipment in distribution networks that must meet existing standards. This study discusses the evaluation of the coordination of overcurrent relay protection and ground disturbance relays on feeders connected to Transformer 2 and Transformer 3 GIS Cow Coop using ETAP 12.6 application [4]. Protection equipment commonly used in medium voltage systems is a power breaker whose work is governed by an overcoming 20 kV overcurrent relay delivering electrical power to several outgoing feeders. Between PMT Incoming 20 kV and PMT Outgoing 20 kV there must be good coordination. But in fact, some of the disturbances are due to protection coordination errors. Poor protection of coordination can cause overlap between the safety at incoming 20 kV and the safety at outgoing 20 kV and cause blackout in all feeders [5]. The protection system is a system that is very urgent or important in the electric power system, because the electric power system cannot be free from interference. The type of interference itself is due to the short circuit current which causes the current to flow quite large and the interference due to interruption of conductor. Judging from the effects caused by a disturbance, short circuit requires much greater attention than the open circuit (Stevenson, 1993) [6].

1. Electric Power System

The electric power system is a system of channeling electrical energy from sources to the load, the system consists of several series of main installations for the distribution of electrical energy including power plants, transmissions, distribution, and consumers or loads. If seen in the picture above the process of electricity to consumers is sufficient many, at the start of the power plant here usually use a generator to convert from motion energy into electrical energy while the turbine moves to rotate depending on the generator used if the power plant then moves the turbine with steam from coal fuel, while if the hydropower then moves the turbine with steam from water that has been removed from its mineralization content, or PLTD which requires diesel fuel which will later become a prime mover in diesel. After work, the diesel engine will produce purely mechanical energy that can drive the generator motor, as well as other power plants. The essence of all kinds of generators is what material is used to move the turbine to the generator. The resulting voltage from this generator is usually 10KV - 12KV. then channeled to the transmission network to increase the voltage in accordance with Indonesian standards the range of voltage 70KV - 120KV or 500KV the function of increasing the voltage is to reduce power losses the higher the voltage eats the smaller the power losses, the transmission network is also commonly referred to as SUTET (extra-high air ducts) installed in the air or SKTT installed underground. In the distribution network the voltage is lowered to 20KV called TM (medium voltage) then the voltage is lowered again according to the needs of consumers divided into two, namely three phases which have 380V voltage that customers use in general such as factories, industrial houses or malls and 1 phase has 220V voltage is used by the wider community for daily needs.

2. Substation

Substations (electrical substation) systems that still have a high voltage of 20 kV or commonly called main substaion then channel it to other substations all of which are step down or reduced in accordance with the voltage required by the load, the total overall substation in PT. Pertamina RU VI balongan namely 13 substations 1 of them as main substation (the parent) and the other as a distributor to the load with a lower voltage. The Substation has several functions as follows:

a. Transforming electrical power by changing the voltage for distribution of electrical energy to a load with a fixed frequency.

b. As a means to measure, monitor operations and to secure the electric power system

c. as a means of regulating power to the substation or other substations through high voltage lines and to distribution substations after going through the process of changing the voltage level through a medium voltage feeder.

d. As a means of telecommunications / liaison in general for inter-system problems that will support one another and internal from PLN.

Figure 1. substation

3. The main electrical component on substation

In a substation in carrying out and fulfilling its objectives and functions properly, the substation is equipped with electrical equipment to support the operation of the substation, as follows:

a. Power Transformer (Potential Transformer)

b. Current Transformer

c. Voltage transformer

d. Power Breakers (PMT)

e. Separator (PMS)

f. Control Panel Device

g. Lightning Arrester (LA)

h. Protection Relay

i. Transformer

j. Busbar and electric cable

II.2 safety protection

In the electricity system there are generators to generate electricity and also the burden (consumers) as receivers of electrical energy and there are several systems that are passed through a case of transmission networks, distribution networks and then the burden and in reality electricity reaching the community is not as easy as the theory learned or in applications that have been simulated, there are many interference factors in the field such as natural disturbances, interference with the tool factor itself and many other ways to overcome them by installing a protection system on the main or sub main means that there must be a good coordination of the protection system such as the transformer namely OCR installed and as overcurrent protection on the transformer so that the tool can be saved from damage,

1. Transformer Protection Relay Equipment
a. Overcureent Relay

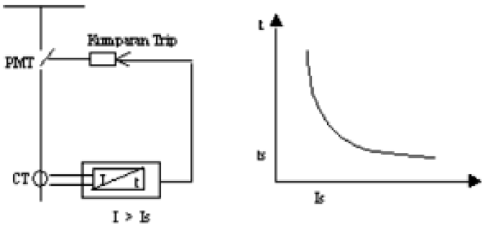


Figure 2 overcurrent relay

Overcurrent current relay is a relay where it works based on an increase in current through it. So that the tool is not damaged if there is a current that passes through its ability, in addition to the equipment being secured against rising currents, the safety equipment must work in accordance with the specified time. The working principle of overcurrent relay is that the relay will work if there is an overcurrent, relay Overcurrent relay will work if there is a current through it that exceeds the current setting value. This relay works from the input value in the form of the amount of current flowing to it which then compares with the value of the relay setting. If the current reading value in the Overcurrent relay exceeds the setting value, the relay will give a warning to the power breaker or Circuit Breaker (CB) for trip (off), after the set delay time.

2. Overcurrent Relay Setting Calculation Theory

In setting an overcurrent relay usually by calculating the results of the calculation of fault current due to short circuit, which will be used to overcurrent settings, especially the Time Multiple Setting (TMS) setting of the overcurrent relay characteristic type of inverse standard. In order to get the secondary setting value for deset on the OCR relay it is necessary to calculate using the Current Transformer (CT) which is mounted on the primary and secondary side of the power transformer.

$$Iset(sek) = Iset(prim) \times \frac{1}{ratio\ CT} \quad (1)$$

where,

Inom: Nominal current in the transformer
Iset: Flow Settings
Iset (Prim): 1.05 x Inom transformer
CT ratio: current transformer ratioFigure 4 shows

As for the current setting in Overcurrent relay is calculated based on the load current flowing on the incoming or outgoing side, namely for working Overcurrent relays installed in outgoing incoming incoming feeders is calculated based on the nominal current of the power transformer and for the work of Overcurrent relays coupled in outgoing.

Tabel 2. 1 Konstanta Karakteristik OCR Standar ANSI/IEEE dan IEC

Tipe kurva	Standard	α	β	L
Moderately inverse	IEEE	0.02	0,0515	0,114
Very inverse	IEEE	2.0	19,61	0,491
Exstremely inverse	IEEE	2.0	28,2	0,1217
Inverse	COS	0.02	0,0239	0,0169
Short-time inverse	CO2	0.02	0,0239	0,0169
Standard inverse	IEC	0.02	0,14	0
Very inverse	IEC	1.0	80,0	0
Extremely inverse	IEC	2.0	80,0	0
Long-time inverse	UK	1.0	120	0

The IEEE Std 242-2001 standard states that the grading time value is 0.2-04 seconds. This is influenced by:

a. Error working relay
b. Safety factor
c. PMT opening time until the fire is gone.
1. Interference outside the protected area

As for calculating the short-circuit current and the current on the primary and secondary sides of the feed used the following formula:

• Current on the primary side

$$Iset(primer) = 1,1\ X\ Ibeban \quad (2)$$

where,

1,1 = constant
Ibeban = Load current

• Current on the secundery side

Iset (sekunder) = Iset (primer) x 1/Rasio (3)

CT

where,

Iset (primary) = Current setting on the primary side

CT ratio = current transformer ratio

• 3-phase short circuit

$$I = \frac{Vph}{\sqrt{Z1eq}} \quad (4)$$

• 2-phase short circuit

$$I\ 2fasA = \frac{Vph-ph}{\sqrt{Z1eq+Z2eq}} \quad (5)$$

• 1-phase short circuit

$$1fase - ground = \frac{3\times Vph}{\sqrt{Z1eq+Z2eq+Z0eq}} \quad (6)$$

3. impedance calculation

Impedance is the equivalent AC resistance to the DC system with the addition of the reaction effect. Impedance is symbolized by the letter Z and is the sum of the vectors between resistance and adhesive.

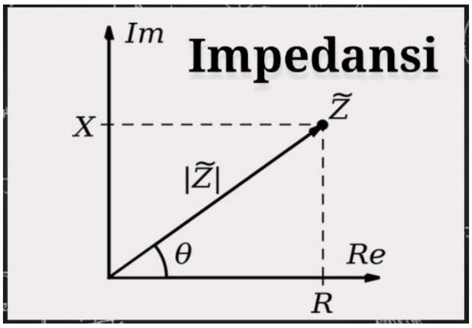


Figure 3. hubungan grafik impedansi

With an equation equation:

$Z = R + j$

Where,

Z = Impedance (Ω)

R = Resistance (Ω)

X = Reactance (Ω)

To find out the value of impedance in a system, use the following formula:

a. cable impedance calculation

$$Z = R + jX \quad (7)$$

Where:

Z = Impedance

R = Resistance

X = reactance

b. transformer impedance calculation

$$Ztrafo = z\%\frac{vp^2}{s} \quad (8)$$

Where:

Ztrafo = Transformer Impedance (Ω)

Z% = Percentage of Transformer Impedance

Vp = Transformer Primary Voltage (V)

S = Maximum Power of Transformer (VA)

c. source impedance calculation

$$Zs = \frac{v^2}{Psc} \quad (9)$$

where,

Zs = source impedance (Ω)

V = source voltage (V)

Psc = short circuit (VAsc)

d. Time Multiple Setting (TMS)

$$t = \frac{\beta\times TMS}{\left(\frac{Ifault}{Iset}\right)^{\alpha}-1} \quad (10)$$

Where:

TMS: Time Multiple Settings

t: Trip time (s)

Ifault: The magnitude of the short-circuit fault current (A)

Iset: the amount of current setting on the primary side (A) The inverse OCR setting is taken as standard (BS) 1.05 to 1.3 x Ibeban

α, β: Constants

e. Calculation of Nominal Flow

$$in = \frac{S}{\sqrt{3\times V}} \quad (11)$$

Where,

In = nominal current strength (A)

S = apparent power (VA)

V = voltage (V)

f. Short-circuit current calculation

$$I = V\ R \quad (12)$$

4. Sofware ETAP

ETAP or (Electric Transient and Analysis Program) is software that is used to analyze electric power systems or to design schemes. The ETAP12.6 software can work offline for electric power simulations and can be used for real data online or to use the system in real time. As for the various features therein including features used to analyze power plants, transmission systems and electricity distribution systems. As for some analyzes for the electric power system that can be done on the ETAP 12.6 software, including:

a. Load flow analysis

b. Short circuit analysis (Short circuit

analysis)
c. Motor starting
d. Arc flash analysis
e. Harmonics power system
f. Transient stability analysis
g. Protective device coordination

III. Methodology

This research methodology includes a literature study, field surveys, expert discussions, and simulations using ETAP software. A literature study can be done by looking for references related to the protection system theory on the main transformer and the theory of overcurrent relays, which are used as the main protection relay in the main transformer at Unit 14 Pertamina RU VI Balongan Indramayu, Jawa Barat area.

The field survey method was carried out by conducting a visit to PT Pertamina RU VI Balongan Indramayu, Jawa Barat, followed by a discussion with the field supervisor.

Discussion activities with experts and also to employees, supervisors, and electrical and instrumental managers at PT Pertamina RU VI Balongan Indramayu, Jawa Barat, regarding the problem to be analyzed. The dialysis issue is related to the operation of overcurrent relays in handling power transformer use current transformer for a find a problem. The authors discuss the overcurrent relay settings so far in the field; then the authors carry out simulations using ETAP software for validation.

The authors simulated interference with power transformers that experienced internal and external disturbances; then overcurrent relays did their job of deciding interference. The simulation is done using ETAP 12.6 software.

IV. Results and Discussion

To find out the performance of overcurrent relays, we need actual data from the company, about the data can be seen from the following table:

1. Single Line Diagram Data of PT. Pertamina VI Balongan Indramayu, West Java

In research conducted within 30 days, there are wiring of electricity distribution or Single Line Diagrams created by Engineer design experts who function as an overall picture of the electricity distribution in PT. Pertamina RU VI Balongan Indramyau, West Java so that it can easily analyze and operate the electrical system

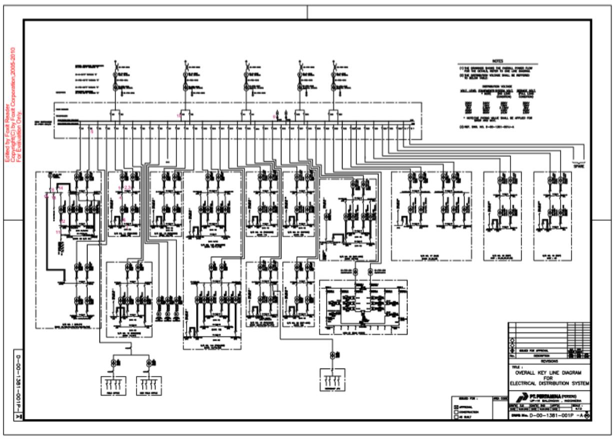


Figure 4.1 Single Line Diagram of Electricity Distribution of PT Pertamina RU VI Balongan, West Java

2. Data Transformer

In Pertamina RU VI Balongan Indramayu, West Java precisely in substation 14A-PTR1-01B there are 2 transformers where two as a step down from 20kv to 3.15 kV and one of them from 3.15 kV step down to 420 V is related to the explanation can be seen in Table 4.1.

Table 4.1 Specification of power transformer

Transformator 14A-PTR1-01B	
Merk/type	NEI peebles. Ltd
Srial number	1BDA3506
Years of manufactor	205
Rating power	288,7/1832,9
Frequency	50 Hz
Impedance %	10,13%
Phase	3 Fasa
Primer voltage	20 KV
Sekunder voltage	3,15 KV
Connection symbol	Dyn11
Standard	IEC
Cooling	ONAN
Height	2.970 mm
Weight	20.600 kg
Short sircuit 20 kv	40 A

3. Current Transformer Specifications Data

In this discussion the current transformer uses as a tool to transform from large currents to smaller currents and also functions as a sensing which later as a current detector when encoded overcurrent on the network, CT (Current Transformer) as a senser and PMT (Breaker) or CB (circuit breaker) as executor, related to specifications can be seen in table 4.2.

Table 4.2. Setting Current Transformer

Voltage ratio	20 kv
Short time current	40A/1 Sec
Insulation level	325 Kv/750kVp
Frequency	50 Hz
1 Dynamic	100 KAp
Rating factor	1
Type	NEI
Year	2009
Creepage Distance	5270 mm
Rated power	10 MVA

4. Overcurrent Relay Data Settings at PT. Pertamina Persero VI Balongan Indramayu, West Java

Table 4.4. Overcurrent Relay Data Settings

Relay di sisi 20 kv					
Relay	Arus (A)	Ratio CT (A)	Karakteristik invers		
			I set	TMS	T (s)
OCR	6A	400/5	1,2	0,4	0,05-2,4

Relay di sisi 3 kv					
Relay	Arus (A)	Ratio CT (A)	Karakteristik invers		
			I set	TMS	T (s)
OCR	5 A	2000/5	0,9	0,3	0,05-2,4

5. Conductor Data Used in PT. Pertamina RU VI Balongan Indramayu, West Java.

Table 4.3. Cable Substation 14A-PTR1-01B

Substation	Jenis konduktor	Diameter konduktor	Panjang jaringan
14A-PTR1-01B	PRD	240 mm2	15 km

Table 4.3. Cable Substation 14A-PTR1-01B

Jenis konduktor	Diameter konduktor	Urutan positif/negatif	Urutan nol
PRD2	240 mm2	0,324 + j0,075	1,0773 + j0,1845

6. Mathematical Calculations and Over Current Relay Analysis

On the electric power system there are several tools or components that require reliable protection or safety. This system is also given a barrier between the tissues so that it is coordinated with the patient, to determine the relay settings on the incoming and 0utgoing 20 kv sides, the following parameters are required:

a. Calculation of source impedance
b. Short-circuit current calculation
c. Incoming relay work time must be longer than outgoing relay work time.

a) Calculation of source impedance

Based on data that has been obtained at PT. Peramina RU VI Balongan, the magnitude of the 3phase short circuit bus 26 voltage 20 kv is 77.6 kA then to calculate it uses the following formula:

$$MV_{HS\,TT} = \sqrt{3V}.I$$

$$MV_{HS\,TT} = \sqrt{3V}.I$$

$$= \sqrt{3.20}.77{,}6$$

$$= 1{,}7.20.77{,}6$$

$$= 2{,}688{,}142 \text{ MVA}$$

So the positive, negative and zero sequence impedances are:

$$Z_{S1} = \text{J}0{,}003692$$

$$Z_{S2} = \text{J}0{,}003692$$

$$Z_{S3} = \text{J}0{,}003692$$

b) Short-circuit current calculation

Then the total reactance on the

transformer 14A-PTR1-01B can be stated as follows:

$$XT(pada\ trafo) = \frac{kVA^2}{MVA}$$

$$XT(pada\ trafo) = \frac{20^2}{10} = 40$$

Then the reactor value of the power transformer is:

- Urutan positif dan negative $XT_1 = XT_2$

$XT_1 = 13\% \times 40 = 5{,}2$

Maka hasil urutan positing dan negatif adalah 5,2

- Urutan nol

Dnyn11 maka besarnya $XT_1 = XT_0$ maka nialainya adalah 5,2 Ω

c) Incoming relay work time must be longer than outgoing relay work time.
based on the data obtained by the type of conductor (cable) used at PT. Peramina RU VI Balongan, precisely at 14A-PTR1-01B uses a type of HAB 240 m2 and has a length of 15 m, the distribution channel impedance consists of positive sequence impedance, sequence impedance negative and zero sequence impedance to calculate it then use the following formula:

- Nilai impedansi Z0

$$Z_0(XLPE\ 240\ mm2 = isequence\ impedance\ zero\ x\ length\ of\ incoming$$

$$= 1{,}0773 + j0{,}1845\ \Omega/\text{km} \times 15\ \text{km}$$

$$= 16{,}1595 + j\ 2{,}7675$$

so we get the value in table 4.4.

Table 4.5. Impedance Results

Impedansi	**Jarak**	**Urutan positif/negatif**	**Hasil**
Z1=Z2	0%	0X (0,324+ j0,075)	0 ohm
Z1=Z2	3%	3 X (0,324+ j0,075)	0,972 + j0,225 ohm
Z1=Z2	**6%**	**6 X** (0,324+ j0,075)	1,994 + j0,45 ohm
Z1=Z2	9%	9 X (0,324+ j0,075)	2,916 +j 0,675 ohm
Z1=Z2	12%	12X (0,324+j0,075)	3,888 + j0,9 ohm
Z1=Z2	15%	15X (0,324+j0,075)	4,86 +j1,125 ohm

d) Calculation of short circuit current

- phase short circuit.
Then to get a 3phase short circuit current can be calculated as follows:

$$I = \frac{Vph}{\sqrt{Z1eq}}$$

Table 4.5. Impedance Results

Panjang jaringan	Perhitungan	Arus gangguan hubung singkat 3 fase (A)
0%	$\frac{1818}{\sqrt{0^2 + 1{,}0294502^2}}$	1.765,9
3%	$\frac{1818}{\sqrt{00{,}972^2 + 1{,}2544502^2}}$	1.145,5
6%	$\frac{1818}{\sqrt{1{,}99^2 + 1{,}4794502^2}}$	733,1
9%	$\frac{1818}{\sqrt{2{,}916^2 + 1{,}6694502^2}}$	596,4
12%	$\frac{1818}{\sqrt{3{,}888^2 + 1{,}9294502^2}}$	418,8
15%	$\frac{1818}{\sqrt{4{,}86^2 + 2{,}15445502^2}}$	341,9

e) nilai setting ocr pada sisi ougoing 3,15 kv dan 20 kv

Table 4.6. value incoming setting

Relay Penyulang	Nilai Setting hasil perhitungan	
OCR	TMS	0,234
	Rasio CT	2000/5 A
	t (s)	1 s
	Iset Primer	352 A
	Iset Sekunder	4,95 A

Table 4.7. value outgoing setting

Relay outgoing	Nilai Setting hasil perhitungan	
OCR	TMS	0,234
	Rasio CT	400/5 A
	t (s)	1,1 s
	Iset Primer	317,54 A
	Iset Sekunder	11,95A

f) perbandingan setting relay terpasang dan terhitung

Table 4.8. relay comparison

Nama relay		Rele terpasang		Relay terhitung		Standard IEC
		Sisi incoming	Sisi outgoing	Sisi incoming	Sisi outgoing	Waktu kerja relay
OCR	TMS	0,4	0,3	0,3	0,1	0,2
	Ratio CT (A)	400/5	2000/5	400/5	2000/5	-
	t(s)	1,2	0,9	1,1	1,0	9,7

g) Simulasi kerja overcureent relay menggunakan software ETAP 12.6

- simulation normal condition

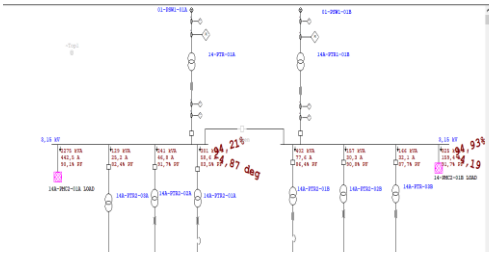
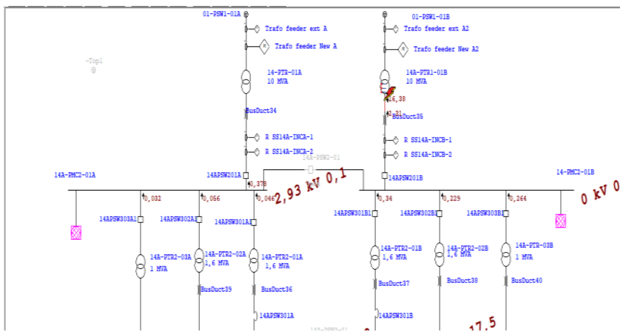


Figure 4.2. normal condition

- simulation Overcurrent relay incoming side



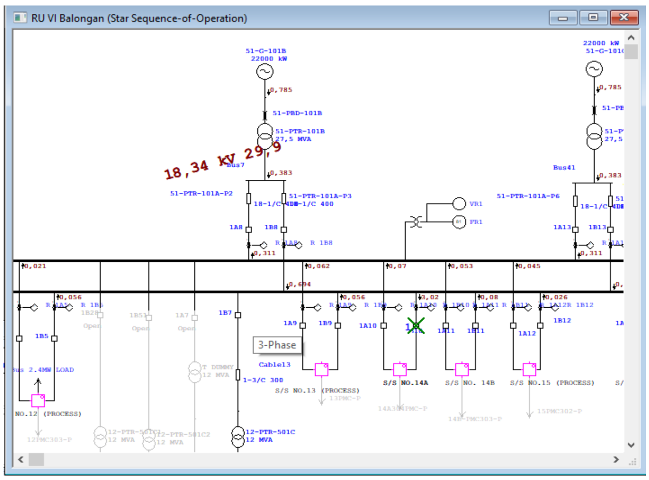


Figure 4.4. simulation incoming side

- simulasi proteksi Overcurrent relay sisi outgoing

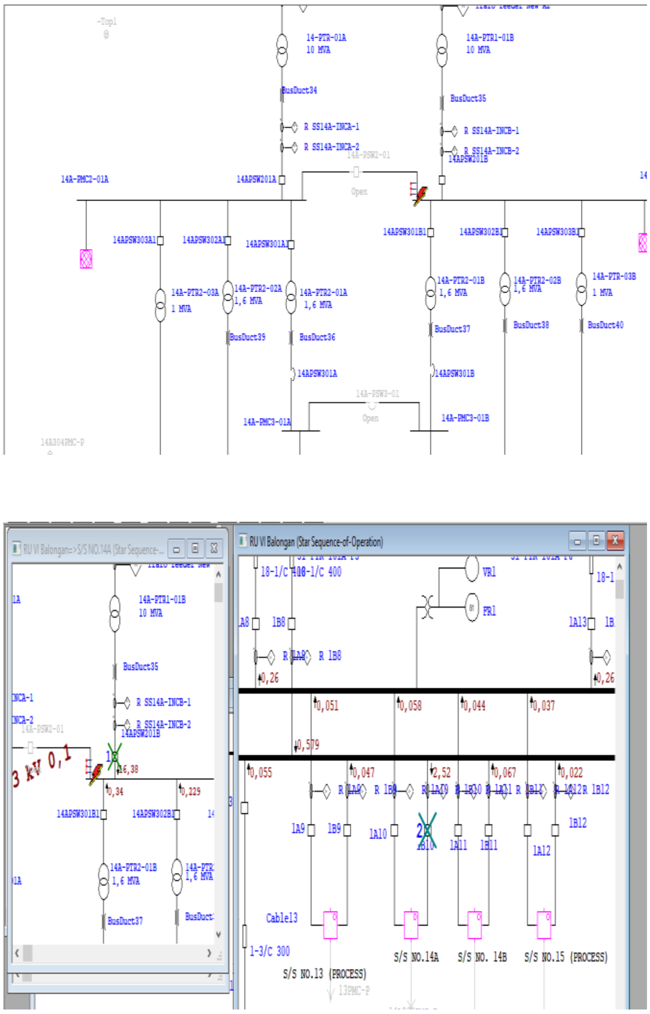


Figure 4.5. simulation outgoing side

V. Conclusion

1. Based on calculations that have been done from the data that has been obtained at PT. Pertamina RU VI Balongan Indramayu, West Java, it can be seen that the values on I set (primary) and Iset (secondary) on the incoming and outgoing sides are in accordance with the data in the field this can be seen from the short circuit analysis where the relay working time after working with multiply for example on a 3 phase short circuit at the point of interference 0% which has a short circuit current value of 1765.9 A then multiply the constants divided by Iset (primary) that is 528 A results of the relay working time for 1 second on the outgoing side and 1.2 seconds on the incoming side means the relay on the outgoing side works faster when compared to the incoming side this happens because the relay on the outgoing side becomes the main protection and the second success benchmark is that the ETAP 12.6 software has been able to detect the short circuit in the second simulation, namely the short circuit on the incoming and o utgoing.

2. Based on the analysis it has been done, it can be seen that the manual calculation when compared to the application calculation etap 12.6 is appropriate there is only a difference of 0.2 on the outgoing side and 0.1 on the incoming side of the TMS (time multiple setting) Overcurrent relay where the value of the manual calculation is the incoming side is 0.3 seconds while in the application 0.4 seconds as well as the outgoing side the calculation value is 0.1 and the Etap 12.6 application is 0.3. There is a difference factor because the calculated data may not be as complete as the data in the ETAP 12.6 application simulation. This happens because of incomplete data.

References

Darmanto, N. A., Handoko, S., Elektro, J. T., & Diponegoro, U. (2006). *Analisa Koordinasi Ocr - Recloser Penyulang Kaliwungu 03*. *8*(1), 15–21. https://doi.org/10.12777/transmisi.8.1.15-21

Fitriyani, M. O., & Facta, M. (2015). *Evaluasi Setting Relay Proteksi Generator Dan Trafo Generator Di Pltgu Tambak Lorok Blok 1*.

Salsabila, S. S., Akuntansi, P. S., Ekonomi, F., Bisnis, D. A. N., & Surakarta, U. M. (2016). *Disusun sebagai salah satu syarat menyelesaikan Program Studi Strata I pada Jurusan*. 1–11.

Trafo, D. A. N., Kandang, G. I. S., Ke, S., Luluk, P., Sruput, D. A. N., Etap, M., … Facta, M. (n.d.). *EVALUASI KOORDINASI PROTEKSI RELAY ARUS LEBIH TRAFO 2 Metode*.

Wirawan, B. (2014). *Setting Koordinasi Over Current Relay pada Trafo 60 MVA 150 / 20 Kv dan Penyulang 20 KV*. *18*(3), 134–140.

Pramitasari, Anggi. 2013. Studi Koordinasi OCR dan GFR Incoming 20 kV Dengan OCR dan GFR Outgoing 20 kV Feeder Kudus 04 di Gardu Induk Kudus. Penelitian (tidak diterbitkan). Semarang: Politeknik Negeri Semarang

Dewi, Sartika. 2013. Koordinasi Setting Rele Arus Lebih dan Rele Gangguan Tanah pada Incoming 2 dengan Penyulang KDS 4 dan KDS 5 pada Jaringan Double Circuit. Penelitian (tidak diterbitkan). Semarang: Universitas Diponegoro

Affandi, Irfan. 2009. Analisa Setting Rele Arus Lebih dan Gangguan Tanah pada Penyulang Sadewa di

GI Cawang. Skripsi (tidak diterbitkan).Jakarta: Universitas Indonesia.

Sarimun, Wahyudi N., Ir., M.T. 2012. Proteksi Sistem Distribusi Tenaga Listrik Jakarta : Garamond

Pribadi K, Wahyudi. Analisa Sistem Tenaga.. (t.t) Materi Pelatihan (tidak diterbitkan). Jakarta: PT. PLN (Persero) Pusat Pendidikan dan Pelatihan.

Authors' information

Fahmi Ilhami received S.T degree from Department of Electrical Engineering, Muhammadiyah Yogyakarta university, Yogyakarta, Indonesia, in 2020.
His research interests are in relay protection and distribution system and power system protection.

Ramadoni Syahputra received B.Sc. degree from Institut Teknologi Medan in 1998, M.Eng. degree from Department of Electrical Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia in 2002, and Ph.D degree at the Department of Electrical Engineering, Faculty of Industrial Technology, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia in 2015.
Dr. Ramadoni Syahputra is a Lecturer in Department of Electrical Engineering, Faculty of Engineering, Universitas Muhammadiyah Yogyakarta, Indonesia. His research interests are in computational of power system, artificial intelligence in power system, power system control, the application of fuzzy logic in power system, optimization, distributed energy resources, and renewable energy.

Anna Nur Nazilah Chamim received S.T degree from Muhammadiyah Yogyakarta university in 2001, M.Eng. degree from Department of Electrical Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia in 2015, His research interests are electronic signaling systems.

Anna Nur Nazilah Chamim is a Lecturer in Department of Electrical Engineering, Faculty of Engineering, Universitas Muhammadiyah Yogyakarta, Indonesia. His research interests are electronic signaling systems.

Kunnu Purwanto received S.T degree from Muhammadiyah Yogyakarta university in 2001, M.Eng. degree from Department of Electrical Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia in 2015, His research interests are electronic signaling systems.

Kunnu Purwanto is a Lecturer in Department of Electrical Engineering, Faculty of Engineering, Universitas Muhammadiyah Yogyakarta, Indonesia. His research interests are electronic signaling systems.