Defence Scheme on Madura Island Against System Loading Variation for Energy Security

Novian Patria Uman Putra[a], Titiek Suheta[b], Nasyith Hananur Rohiem[c], Trina Wati[d], D. M. Ariyanto and Lestarina Tampubolon

Electrical Engineering Department, Institut Teknologi Adhi Tama Surabaya, Jl. Arif Rahman Hakim no.100, Surabaya, Indonesia

Keywords: Defence Scheme, Overload Shedding, Overcurrent Relay, Energy Security.

Abstract: One of the obstacles that often occurs in the distribution system is overloading. It happens because of the high demand for consumer expenses or the criteria of N-1 in the distribution system not being met. In other words, when there is a disturbance in one of the conductors in the electric power distribution system, the other conductor will experience overloading (above the nominal). Therefore, the Defence Scheme must be implemented as it serves as a defence strategy that aims to maintain or restore the system to a normal state and prevent widespread blackouts and for energy security. The implementation of the defence scheme happened at the Ujung-Bangkalan Bay Line by adding safety equipment, namely an Overload Shedding (OLS) relay. The work of Overload Shedding Relay (OLS) was coordinated with the Overcurrent Relay (OCR). OLS and OCR would be simulated using the DigSILENT. The result of the simulation demonstrated the coordination between OLS and OCR during the overloading execution. The simulation was carried out based on the distribution data through the Ujung-Bangkalan conductor. When the OLS failed to work, it would activate the OCR for the Ujung-Bangkalan conductor so that the Ujung-Bangkalan electricity supply was cut off and the blackouts spread.

1 INTRODUCTION

Using Security in the distribution of the electric power system is very important. The fulfillment of the N-1 criteria in the distribution system is of greater concern. In a sense, if there is a disturbance in one of the conductors of the distribution system of the electric power system, there will be an overload on the other conductor (Anung & Achirul Ramadhani, 2017). The implementation of the defense scheme on the electricity system on Madura Island is carried out by coordinating the work of the overload shedding (OLS) relay against the overcurrent relay (OCR).

OLS will play a role in securing equipment from overload so that it can minimize the occurrence of widespread blackouts. The application of the OLS relay at the Ujung Substation is critical in order for the OLS relay to work first rather than the short circuit safety relay like Over Current Relay (OCR) when the electric power distribution line towards Madura Island is overloaded. OLS is expected to be able to select priority loads and determine the load to be released to prevent widespread blackouts. Therefore, the OLS and OCR settings must be coordinated to secure interference(U. Induk et al., 2020).

2 METHODOLOGY

In the system, for the implementation of a defense strategy for the operation of the electric energy system, which aims to maintain or restore the system to normal operating limits and prevent widespread

[a] https://orcid.org/0000-0001-9027-4707
[b] https://orcid.org/0000-0001-9027-4707
[c] https://orcid.org/0000-0001-9450-3140
[d] https://orcid.org/0000-0001-8431-1911

Putra, N., Suheta, T., Rohiem, N., Wati, T., Ariyanto, D. and Tampubolon, L.
Defence Scheme on Madura Island Against System Loading Variation for Energy Security.
DOI: 10.5220/0012114800003680
In *Proceedings of the 4th International Conference on Advanced Engineering and Technology (ICATECH 2023)*, pages 210-214
ISBN: 978-989-758-663-7; ISSN: 2975-948X

disturbances and even blackouts, the Defense Scheme function is used when a disturbance occurs that has the potential to hamper system stability.

The purpose of the defense scheme is to maintain system supply (500/150 kV conductors and IBT) in order to survive abnormal conditions caused by disturbances in electrical equipment, prevent widespread disturbances, and save thermal generators with the aim of avoiding expensive start-up costs and speeding up the recovery process.

2.1 Overload Shedding (OLS)

Overload Shedding is an important concept in the defense scheme strategy's implementation, as OLS works when there is an overload condition when setting a time period on electrical equipment. The working principle of OLS is to release the load gradually and automatically so that the equipment does not experience blackouts and can return to operation below its nominal value (U. Induk et al., 2020).

One of the disturbances that can cause overcurrent is overload. Therefore, the Over Load Shedding (OLS) setting will be coordinated with the Over Current Relay (OCR) setting in the 20 kV Incoming Transformer. As a result, when the PMT disconnects, the error does not occur during discharge and there is an indication of the working relay (A. A. S. P. Larekeng & M. Iqbal, 2020; Anung & Achirul Ramadhani, 2017; A.W Hidayat, 2013; E. Pafela & E. Hamdani, 2016; I. Hajar & M. Ridho, 2020; T. Nova, 2013).

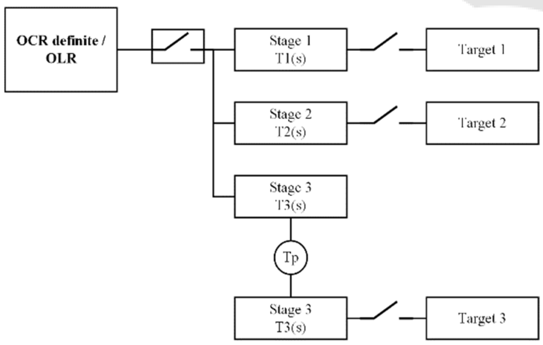

Figure 1: Load Shedding Scheme with OLS.

When there is an overload, OLS will reduce the load by tripping the target according to what has been set on the OLS relay(Anung & Achirul Ramadhani, 2017). OLS works in three stages, and each stage has a different trip time. If OLS fails to work, then OCR will work and trip the line it protects

2.2 Over Current Relay *(OCR)*

Overcurrent relays(T. Nova, 2013) can be said to be equipment whose function is to sense when there is an overcurrent caused by a short circuit or an overload that can damage equipment in the protected area. As for the ground fault relay, it will detect if there is a short circuit to ground. The single-line diagram (T. Nova, 2013) of the relay is as follows:

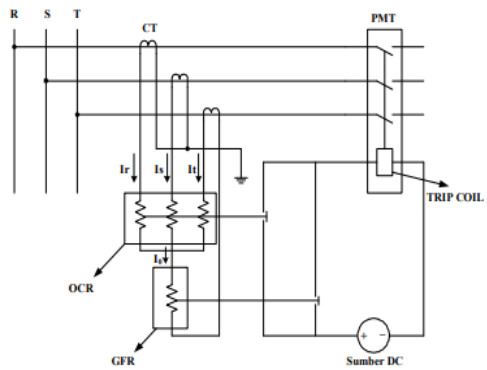

Figure 2: Single Line OCR and GFR.

2.3 Current and Time Setting on OCR and OLS

The formula for setting current and OCR times is found in equations (1) and (2). Then, in equations (3) and (4), the current and time formula for OLS coordinated with OCR is found. The calculation of OLS(Anung & Achirul Ramadhani, 2017)(T. Nova, 2013) and OCR(T. Nova, 2013) is based on the calculation of SPLN T5.002-1:2010 as follows:

- Current Setting OCR

$$Is = 1.2 * In \quad (1)$$

Wherein :
Is = Current Setting for OCR (Ampere)
In = The smallest nominal current in a conductor (Ampere)(*SPLN T5.002-1:2010 Standar Pola Proteksi*, 2010)

- Time Setting OCR

$$TMS = \frac{(If/Is)^{0.02}-1}{0.14} * T(SI) \quad (2)$$

Wherein :
TMS = Time Multiple Setting
If = Short Circuit Current
Is = Current setting
T(SI)= Working Time Relay (Value 1)(PT. PLN (Persero), 2010)

- Current Setting OLS

$$Is = 1.1 * In \quad (3)$$

Wherein :
Is = Current Setting for OCR (Ampere)
In = The smallest nominal current in a conductor (Ampere)(PT. PLN (Persero), 2010)

- Time Setting OLS

For setting the time used in the OLS relay, it uses definite time characteristics and has a gradual setting time(U. Induk et al., 2020).

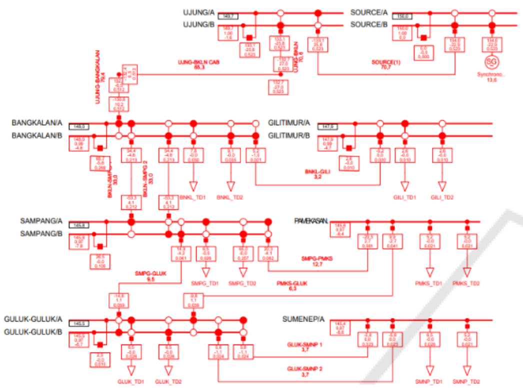

Figure 3: Subsystem 150 kV Ujung – Bangkalan.

3 EAST JAVA REGIONAL 4 DEFENCE SCHEME SETTINGS DATA

In order to optimize the load-shedding mechanism, the OLS scheme is created in stages. Overload Shedding (OLS) GI Edge works in 3 stages. These three stages will extinguish the target, namely the transformer on the island of Madura.

a) For Stage 1, with a working current of 710 A, the working rate of 5 seconds opens:
 • PMT 20 kV Incoming Transformer–2 150/20 kV GI Bangkalan (ON/OFF)
b) For Stage 2, with a working current of 710 A, the working rate of 5.5 seconds opens:
 • PMT 20 kV Incoming Transformer–2 150/20 kV GI Sampang (ON/OFF)
 • PMT 20 kV Incoming Transformer–2 150/20 kV GI Sumenep (ON/OFF)
c) For Stage 3 with a working current of 710 A, the working rate of 6 seconds opens:
 • PMT 20 kV Incoming Transformer–1 150/20 kV GI Bangkalan (ON/OFF)
 • PMT 20 kV Incoming Transformer–1 150/20 kV GI Sampang (ON/OFF)
 • PMT 20 kV Incoming Transformer–1 150/20 kV GI Sumenep (ON/OFF) [3].

4 SIMULATION RESULTS

In this section, we will see a simulation of the Defence Scheme on Madura island with variation load as shown to the table 1 below

Table 1: Setting OCR and OLS

Setting	I (Ampere)	t
OCR	760	0.53 SI
OLS Stage 1	710	5.00 DT
OLS Stage 2	710	5.50 DT
OLS Stage 3	710	60 T

OCR must be faster than OLS during a short circuit current fault. However, during overload disturbances, OLS must work faster than OCR.

Table 2: Calculation data for Bangkalan Bay OCR settings in Ujung GIS.

xI>	I (Amp.)		t (second)
	Primary	Secondary	Calculated
1,5	1140	5,7	9,11
2	1520	7,6	5,32
2,4	1824	9,12	4,2
3	2280	11,4	3,34
3,5	2660	13,3	2,92
4	3040	15,2	2,64

The following in Figure 4 below shows the voltage graph data on each bus:

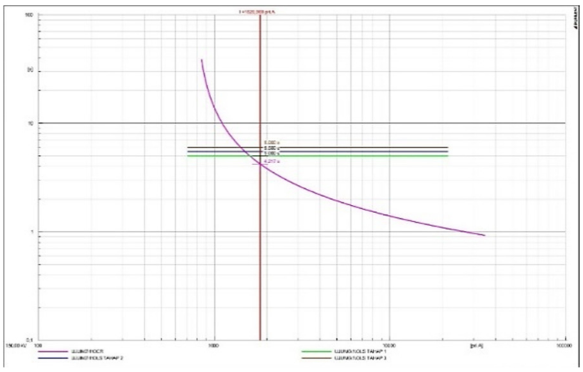

Figure 4: Ujung-Bangkalan OLS and OCR Coordination Curve.

Description
: Current
: OCR
: OLS Stage 3
: OLS Stage 2
: OLS Stage 1
X-Axis : Current Values
Y-Axis : Relay Working Time

Table 3: OCR and OLS Relay Performance Data.

Working Current		686,05	744,9	744,9	744,9	1826,97
OCR T(s)	Calc	~	~	~	~	4,193
	Sim	10000	9999,9	9999,9	9999,9	4,217
OLS T(s)	Std	~	5	5,5	6	-
	Sim	10000	5	5,5	6	-
OLS		-	T1	T2	T3	
Condition		0	1	2	3	4

Description
T1 : PMT 20 KV Trafo 2 GI Bangkalan
T2 : PMT 20 KV Trafo 2 GI Sampang, PMT 20 KV Trafo 2 GI Sumenep
T3 : PMT 20 KV Trafo 1 GI Bangkalan, PMT 20 KV Trafo 1 GI Sampang, PMT 20 KV Trafo 1 GI Sumenep
0 : Normal
1 : OLS Stage 1
2 : OLS Stage 2
3 : OLS Stage 3
4 : OLS Not Working

The effect of OLS work on the load on Madura Island is to prevent widespread blackouts due to overloading by extinguishing some of the load using OLS. The load that was extinguished based on the data of the UP2B defense scheme, namely

- At Stage 1, turn off the load. The target of OLS phase 1 is PMT 20 kV Incoming Transformer-2 150/20 kV GI Bangkalan. The total load that was extinguished was 18.4 MW.
- Turn off the load at Stage 2. The target of OLS phase 2 is PMT 20 kV Incoming Transformer-2 150/20 kV GI Sampang and PMT 20 kV Incoming Transformer-2 150/20 kV GI Sumenep. The total load that was extinguished was 78 MW.
- Turn off the load at Stage 3. The targets of OLS phase 3 are PMT 20 kV Incoming Transformer-1 150/20 kV GI Bangkalan, PMT 20 kV Incoming Transformer-1 150/20 kV GI Sampang, and PMT 20 kV Incoming Transformer-1 150/20 kV GI Sumenep. The total load that was extinguished was 81.9 MW.

Table 4: OLS SUTT 150 kV Load Shedding Ujung-Bangkalan.

Tahap	Total Beban (MW)
1	18,4
2	78
3	81,9

5 CONCLUSION

Based on the results of the analysis and simulation in this thesis research, it can be concluded:

1. The operation of OCR and OLS relays in terms of calculations and simulations is in accordance with the standard calculation provisions regulated by PLN.
2. The coordination of OLS and OCR relays in securing the distribution system has gone well, where OLS works first to secure overload by using 3 stages. The OLS setting is smaller than the OCR setting in order to prevent OCR from working before OLS. OLS stages are distinguished based on the working time. OLS works within 5 DT for the first stage, 5.5 DT for the second stage, and 6 DT for the third stage. And for OCR working time using standard inverse characteristics, namely working time based on the value of the current flowing, the greater the value of the current flowing, the faster the relay works.
3. OLS works according to the calculation of the setting value, which is 710 A, but when OLS fails to reduce the overload, the OCR relay will work, where the current OCR working setting at Bay Bangkalan GIS Ujung is 760 A.

OLS has an effect on reducing excessive loads, namely by extinguishing the load according to the OLS target to prevent widespread blackouts.

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