Load Shedding Simulation Using A Frequency Relay In Lampung Electrical System

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Abstract. Stability is one of the requirements of an electrical power system which can be considered good/ideal. One disturbance that can affect stability is the outage of the system generator. To overcome this problem, load shedding is performed. The load is released in a simulation aimed at bringing the frequency back to the authorized value after the disturbance has occurred. The power plant that experienced a trip in this study was the largest Lampung unit of the generator Tarahan 4. When the generator Tarahan 4 has been tripped, the frequency system is falls and stabilize at 48.8 Hz. Therefore necessary to release the load so that the system frequency returns to the authorized value, which is from 49.8 Hz to 50.2 Hz. Based on the results of simulation after setting the frequency relay, by releasing a load of 152.2 MW, the frequency was stable at 50.074 Hz. So it can be concluded that the frequency relay setting has been able to return the system frequency to allowable value.

1. Introduction
If a generator trips, then the power that was originally generated turns into a lack of production power, this will cause the frequency to drop. If these conditions are not resolved immediately, this may cause a system failure due to the operation of the under frequency relay, and generators operating at frequencies which do not comply with their working frequency limits, will cause excessive vibration in the turbine and can shorten the life of the generator [1]. It is therefore necessary to conduct a study by applying a simulation, this study entitled: "Load Shedding Simulation Using A Frequency Relay In Lampung Electrical System".

The load shedding must be carried out as optimal as possible so that the released load is minimum[2]. Load shedding has several methods, including: load shedding using the Under Frequency Relay (UFR) and Under Voltage Load Shedding (UVLS); Unloading applies the semi-adaptive method, using the Rate of Change of Frequency (RoCoF) relay [3-4]; The load shedding applies the adaptive method. In this method lies in adding the frequency response or called the system frequency response (SFR), SFR contains information such as the governor's response,

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1.1. Electric system of Lampung province

The electricity system of Lampung province is a system interconnected with the electricity system of South Sumatra, so that if Lampung lacks generation, it will benefit from a transfer of electricity from South Sumatra. However, the power transfer has a maximum transfer limit so that the system is still able to maintain its voltage stability (PV curve). In addition, the limited power transfer is also influenced by the MVA nominal value of the interconnected generator. On the other hand, Lampung is very dependent on energy transfer from South Sumatra because the Lampung power plants have not been sufficient to meet the load needs of the region.

At the peak of load on November 5, 2019, the transfers from South Sumatra to Lampung are very high, reaching 336 MW (the highest power transfer on the island of Sumatra). This means that production at Lampung was not sufficient to meet the needs of the load in their own area, so it requires a significant transfer of energy from South Sumatra. Under these conditions, the Lampung electrical system is subject to stability caused by disturbances. The disturbance can be in the form of a generator trip which results in a decrease in system frequency [4]. If the impact is not overcome, it will cause a total breakdown. Therefore, we need a defense system that can prevent total breakdown in the Lampung electrical system. In this study, the authors will apply the charge release scheme using the semi-adaptive method.

2. Research objectives

The objectives of this research are:

- Know the state of the system when the trip is one of the largest power plants in the Lampung subsystem
- Determine the parameters of the RoCoF relay and the amount of charge released
- Analysis of the state of the system after the RoCoF relay has operated

3. Research methods

In this research, the author uses Digsilent Power Factory to analyze the problems observed, Steps to follow before obtaining the RoCoF relay [3] parameters: 1) Data collection, 2) Single line diagram modelling, 3) Power flow simulation, 4) Short circuit simulation, and 5) Generator interference simulation trigger.

4. The Data

Here is the data necessary to build a single-line diagram of the province of Lampung

4.1. Data Generator

![Data Generator](image)

**Figure 1.** Data Generator 1 to 33

4.2. Load data for Substation
4.3 Single Line Diagram of Lampung Electric System

![Single Line Diagram of Lampung Electric System](image)

Figure 3.Single Line Diagram of Lampung SubSystem

Figure 4.Single Line Diagram Modeling using Digsilent Power Factory 15.1

5. Simulation

5.1. Power flow simulation
The power flow simulation aims at verifying the data entered in the system components (such as the generators and the loads) according to the real data of the Lampung subsystem [5-6].

5.2. Simulation of a short circuit interruption
This simulation aims to check if the circuit is correctly connected [5-6]. A three-phase short-circuit disturbance is given on the transmission line 1 which connects Tegineneng Substation and Pagelaran Substation.

5.3. Simulation of trip generator interference
This simulation aims to determine the condition of the system frequency after the generator experiences trip [5-6]. The power plant that experienced a trip in this study was the largest generator Tarahan 4. With a trip time occurring in the 1st second after the simulation is run. The following is the system frequency Fig.5.

When the generator Tarahan 4 has been tripped, the frequency system is falls and stabilize at 48.8 Hz. So it is necessary to release the load so that the system frequency returns to the authorized value, which is from 49.8 Hz to 50.2 Hz.

6. RoCoF relay parameters
To obtain the inertia of the system using the formula:

\[ H_{sys} = \sum_{i=1}^{n} \frac{H_{generator[i]} \times MVA_{generator[i]}}{MVA_{generator[i]}} \]  

(1)
In this case study, the trigger generator is the largest generator, namely Steam Power Plant of Tarahan 4. To obtain the correct system inertia in determining \( \frac{df}{dt} \), the total system inertia must be reduced by inertia of the disturbed unit [3], so that \( H_{sys} = 5.2844 \). Determine the apparent power (MVA) and the value of the active power system (MW) shortly after the disruption of Tarahan steam power plant 4 [7]. Based on Figure 6, the following values are obtained: MW generated by generator = 732.623 MW, MVA generated by generator = 739.867 MVA, MW generated by external network (transfer from South Sumatra) = 221.552 MW, MVA generated by external network (transfer from South Sumatra) = 236.96 MVA, MW load = 941.803 MW.

After knowing the MW and MVA system, the \( \frac{df}{dt} \) calculation is performed = - 0.06 Hz/s. For the RoCoF relay time delay taken at 0.05 seconds, this value is taken from a range of values from 50 to 500mS. This value is within the RoCoF relay tolerance limit to prevent trip errors [3].

The decrease in system frequency is obtained from the ratio between the power supplied by the unit that is interrupted before experiencing disruption to the remaining installed power in the system, \( \frac{df}{dt} = -0.346 \) Hz/s. The number of MW of load that must be released by the RoCoF relay [3] can use the formula:

\[
\frac{df}{dt} = \frac{f_r}{2H} \left( \frac{P_{ load} - (P_{ gen} - P_{ net}) - P_{ R} \delta}{P_{ load} - P_{ net}} \right)
\]

(2)

Where:

\( \frac{df}{dt} \) : Expected changes in frequency after the load is released

Based on simulation, it is known that the RoCoF relay works when the frequency reaches 49.962 Hz and is at 1.405 seconds. So that the PB values are obtained = 941.08 MW. To determine how many MW must be released, obtained = 159.3 MW. So, by releasing a load of 159.3 MW, it is expected that the system frequency will return to the value of 50 Hz. After releasing the load, the frequency had increased to 50.685 Hz at 31.266 s seconds. After that the frequency is stable at 50.074 Hz.

7. Analysis of Simulation Results

The increase in frequency which reaches a value of 50.685 Hz is due to the fact that the system responds to a significant reduction in the MW load due to the operation of the set RoCoF relay [3]. So at that time, the MW load is smaller than the MW generated. But the increase occurred in a short time, so it is still within the frequency tolerance range. After a period of frequency increase, the system frequency is constant at 50.074 Hz, it show at figure 7. Indeed, the conditions for generating MW are proportional to the load MW. The value of 50.074 Hz is a value that is always within the safety frequency limit, where the maximum frequency is 50.2 Hz to be able to operate continuously.
8. Conclusion
Based on the analysis of the data and observations during the practical work, the following conclusions are obtained:

1. Lampung's electrical system is subject to stability which can cause power outages. In fact, the frequency decreases when the largest generator trips. On the other hand, adding power plants requires high costs, so defense plans are needed to maintain the reliability of the system.
2. The RoCoF relay pays attention to the power imbalance when the generator is trip.
3. To determine the number of MW of load released, the increase in frequency $\frac{df}{dt}$ must be equal to the decrease in frequency $\frac{df}{dt}$ but it has a different polarity. The frequency is expected to increase and return to its nominal frequency (50 Hz).
4. The use of RoCoF relays can be used as a defense system for the Lampung system because according to the results of the study. This relay is capable of releasing the load and reaching the authorized frequency.

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References
[1] Zhang, Guorui, 2009, EPRI Power Systems Dynamics Tutorial, Electric Power Research Institute, California.
[2] Bakar, Nur Najinah, et al, 2016, Microgrid and Load Shedding Scheme During Islanded Mode: a Review, Elsevier.
[3] Turaj Amraee, Alireza Soroudi at al, 2017, Probabilistic Under Frequency Load Shedding Considering RoCoF Relays of Distributed Generators, IEEE, DOI 10,1109/TPWRS,2017,2787861.
[4] Alexander Berdin and Pavel Kovalenko, 20018, Defining The Power System Load Frequency Static Response Slope Based On Transient Synchrophasor Data, MATEC Web of Conferences 208, 04002 (2018) https://doi.org/10,1051/matecconf/201820804002.
[5] Putu Agus Aditya Pramana, Buyung Sofiarto Munir, 2016, Modeling and Simulation of Electrical Resonance in EHV Transmission Line Case Study in West Java Region 500 kV System, MATEC Web of Conferences 55, 05005 (2016), DOI: 10,1051/matecconf/20165505005, ACPEE.
[6] Nikolay Yu, Ruban, AlmazO Sulaymanovat al, 2017, Simulation Of A High-Frequency Link Of Phase Comparison Protection Of Transmission Lines For Optimization Its Settings, MATEC Web of Conferences 91, 01050 (2017), DOI: 10 ,1051/matecconf/20179101050, Smart Grids 2016.
[7] Marsudi, Djiteng, 2006, Operasi Sistem Tenaga Listrik, second edition, Graha Ilmu Publisher.