Journal of Industrial Engineering & Management Research
Vol. 5 No. 6
http://www.jiemar.org
e-ISSN : 2722-8878

STABILITY ANALYSIS OF THE POWER SYSTEM AT THE BANTEN 3 LONTAR COAL-FIRED POWER PLANT WITH THE INSTALLATION OF A POWER SYSTEM STABILIZER ON THE 150KV TRANSMISSION SYSTEM OF TELUK NAGA TANGERANG BARU SINDANG JAYA

Muhammad Arief [#1], Suwandi [#2], Eko Kustiawan [#3], Jefri Anarkhi

[#]*Lecturer & Technical Faculty & Indonesia Yuppentek University*
Jl. Veteran No.1 Kota Tangerang

[1] ariefjdsk659@gmail.com
[2] suwandizy2018@gmail.com
[3] eko.kustiawan@gmail.com
[4] jefrianakhinursalam@gmail.com

Abstract* — *In the operation of the electric power system, there are often short circuit disturbances, both permanent and temporary, the use of the connection can cause deviations in the variable variables of the electric power system, such as voltage, frequency.

The load growth on the 150 kV Teluk Naga Tangerang Baru Sindang Jaya (Tangerang) Banten network system is increasing day by day. The cause is the current development of development. The growth of the load increases the possibility that the number of loads will exceed the existing generation capacity in the future. With the growth of the load that continues to increase, the possibility of blackouts increases if at any time there is a problem with one of the plants. Therefore, this is a concern by PLN on plants that are not equipped with equipment to increase transient stability. For this reason, the Banten 3 Lontar PLTU needs a Power System Stabilizer on the generator. Before activating this feature, it is necessary to conduct a transient stability analysis to determine the system's response to the network it is supplied with. Observation of the changes that occur will show how much the Power System Stabilizer has an effect on increasing transient stability. In the final result, it can be seen that the transient stability increases after the use of the Power System Stabilizer

Keywords — *Transmission, Transition, Stability, Load, Power System Stabilizer*.

I. INTRODUCTION

In the operation of the electric power system, one of the most important problems is stability. The imbalance between the mechanical input power and the electrical load power in the system causes the speed of the generator rotor (system frequency) and voltage to deviate from normal conditions so that the stability of the system will be disturbed. System instability is caused by disturbances, both major and minor disturbances. Small disturbances can be in the form of sudden and periodic changes in the load, while large disturbances are caused by errors in the system such as short circuit disturbances, network breaks, and load shifting. If this is not immediately overcome quickly, both in the form of a large disturbance, and the time of the disturbance, the system will work deviate from normal conditions. Therefore, control equipment is needed in the electric power system that is able to react automatically to deviations. Governor control equipment, AVR (Automatic Voltage Regulator), and excitation system are control equipment that must be owned by the electric power system so that the stability of the electric power system can be maintained [1].

At this time, technological development is increasingly rapid, this is marked by the existence of industries and households that use large-capacity electrical equipment, so good voltage quality is needed in the distribution of electric power so that it is well received by consumers according to data for May 2023 the increase in customers in the Lontar sub-system is 6%. Along with the very rapid development in the field of electricity, one of the problems of interference in the electric power system is the existence of transients, where this transient is defined as the phenomenon of rising voltage of thousands of volts and occurs in a very fast time. Because it takes place at a very fast tempo, not all power meters are able to detect transients. Stability in an electric power system is the main thing to ensure the continuity and reliability of the operation of an electric power system. [1].

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Based on the IEEE Transactions on Power Systems paper entitled Definition and Classification of Power System Stability, the stability of the electric power system is categorized into three, namely frequency stability, rotor angle, and voltage [2]. This definition also applies to systems that operate by interconnecting multiple generators (multi machines) [3].

Causes of transients include load switching (splicing and disconnecting loads), capacitance switching, recovery voltage. Interference in transmission or distribution lines can cause transients in the system. Voltage drops and sudden voltage increases can cause electrical equipment to fail or stop operating.

Based on these reasons, the author tries to study the impact of the implementation of PSS to improve transient stability in the 150 kV Teluk Naga Tangerang system.

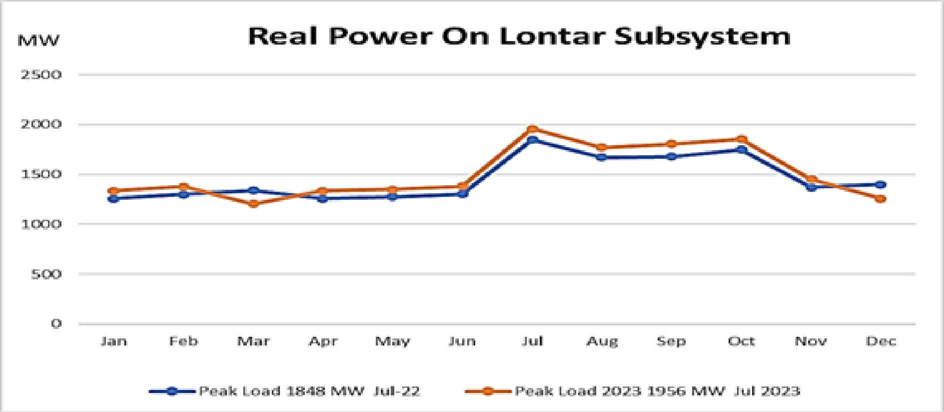

Figure 1. Overview of the increase in customers of the Lontar subsystem

II. TRANSIENT STABILITY

Method for analysis Electric Power Systems in transient stability using model then input for all actual paremeters on site than simulation using Etap.

A. Energy System Stability

Complex Electric Power Systems have many large dynamic loads, the power they absorb varies greatly in a certain span of time, with this change the power supply distributed by the generator must be in accordance with the load needs. The stability of an electric power system in general can be defined as the ability of an electric power system to maintain its synchronous state during and after a disturbance. Based on the IEEE definition and classification of power system stability, the stability of the electric power system is divided into three categories, namely:

Rotor angle stability Rotor angle stability is the ability of a synchronous machine connected to the system to remain in sync after a disturbance. Instability will result in the increase in different rotor angles of the generator so that the generator can lose synchronization with other generators [2].

Frequency stability [1] Frequency stability is the ability of the power system to maintain a stable frequency when interference occurs and after interference. Usually, this disturbance is in the form of a significant change in power generation or load. The frequency standard for Steam Turbine Generators (IEEEStdC37.106-2003) [10] as mentioned of figure 4.

Voltage stability [1] Voltage stability is the ability of the power system to maintain a stable voltage on all buses after a disruption. It depends on the system to maintain a balance between power supply and load, the definition of voltage magnitude as mention of figure 5.

B. Transient Stability

Transient stability is a concept in control systems that deals with how a system responds to a disturbance or sudden change before reaching a new stable state. In this process, the system experiences a transient response called a "transient." Its transient time and stability describe how quickly and well the system can reach equilibrium after a disturbance. Transient stability is the ability of the power system to maintain synchronization when experiencing transient disturbances. This transient disturbance is in the form of major disturbances that occur in the system such as short-circuit disturbances, motor starting, load release and sudden load addition [2].

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The quality of the electrical power system is said to be good if the system is able to maintain stability during emergencies due to disturbances that arise.

C. *Power System Stabilizer*

Dynamic stability in an electric power system is determined by the ability of the generator to respond to changes in load that occur. Sudden and periodic load changes cannot be responded to properly by the generator so that it can have an impact on the dynamic stability of the system. This response can cause frequency oscillations over a long period of time, and lead to a decrease in power transfer capabilities. This can be overcome by adding auxiliary equipment called the Power System Stabilizer (PSS). With the addition of PSS, the dynamic stability of the system will be better [12]. PSS is a device that produces control signals to be fed to the excitation system. PSS has a basic function to increase the limit of stability by regulating the excitation performance of the synchronous generator rotor. Oscillation occurs with an interval of 0.2-0.5 Hz. To provide damping, PSS must provide an electrical torque component to the engine in a phase [1]. The PSS model consists of several blocks as shown in Figure 2.

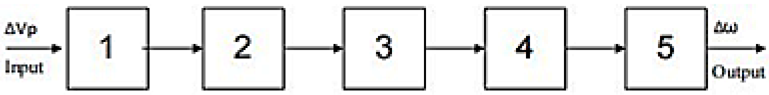

Figure 2. Power System Stabilizer (PSS) Components

Description:
1. Transducer
2. Lag/Lead Phase Series
3. Amplifier
4. Washout Network
5. Limiter

The PSS design method generally involves a response frequency based on the concept of increasing torque attenuation. The PSS transfer function is tuned to provide precise phase-lead characteristics to compensate for the phase lag between the input frequency of the automatic voltage regulator Δvs and the electrical torque [12,8]. So, the electrical torque component is as good as a variation in speed to improve damping. The mathematical modelling of PSS is expressed in equation 1.

$$V_s = K_{pps} \frac{T_{w^s}}{1+T_{w^s}} \left[\frac{(1+T_{1^s})}{(1+T_{2^s})} \frac{(1+T_{3^s})}{(1+T_{4^s})} \right] \omega$$

From the above equation assuming that the output of PSS is Vs with an input of Δω, the block diagram block in Figure 3 is obtained

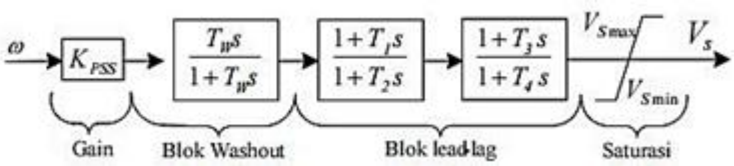

Figure 3. Power System Stabilizer diagram blocks

PSS diagram block description:

a) *Blok Gain*

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It functions to regulate the amount of reinforcement so that the amount of torque is obtained according to the desired amount.

b) *Blok Washout*

The washout serves to provide a steady state bias of the PSS output that will modify the terminal voltage of the generator. The PSS is expected to only be able to respond to transient variations in the speed signal of the generator's rotor and not to the DC offset signal. Washout works as a high pass filter that will skip all the desired frequencies. If only the local model is desired, the Tw value can be selected in the range of 1 to 2. If the area into mode also wants to be muted, then the Tw value should be selected in intervals of 10 to 20. Higher Tw values can improve the voltage response of the system during island operation

c) *Block Lead-Lag*

Lead-Lag serves as a generator of appropriate phase lead characteristics to compensate for the phase-lag between the excitation input and the generator torque

d) *Limit*

The PSS output is limited so that the PSS action on the AVR is as expected. For example, when a load shedding occurs the AVR acts to reduce the generator terminal voltage while the PSS produces a control signal to increase the voltage (because the generator rotor speed increases when the load shedding occurs). In this condition it is very necessary to disable PSS.

D. Standards Used for Transient Stability Analysis

In determining whether an electric power system is stable or not, it is by evaluating the voltage and frequency response of the system. The standards used to determine whether the system is stable or not are:

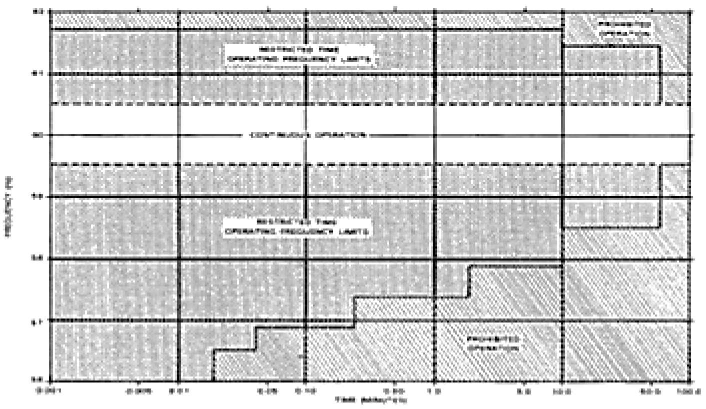

Figure 4. Frequency Standards for Steam Turbine Generators (IEEEStdC37.106-2003)

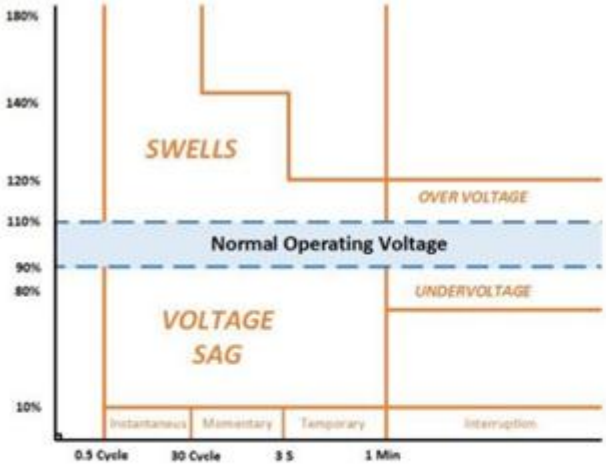

Figure 5. Definition of Voltage Magnitude Event based on IEEE Standard 1195-1995

E. Load Release

Load release is one of the measures to maintain stability. If there is a disturbance such as a generator outage resulting in the available power not being able to serve the load, so to keep the system from blacking out, load release is required.

When the load is in a condition of lack of power supply, it is not allowed to release the load on a large scale. There are two load release schemes that refer to the ANSI/IEEE C37.106-1987 standard [4], namely three-step load release and six-step load release.

The type of PSS used is: Inter area (Long cycle Mode power oscillation)

The entire system oscillates as a result of the large transmission capacity over long distances.

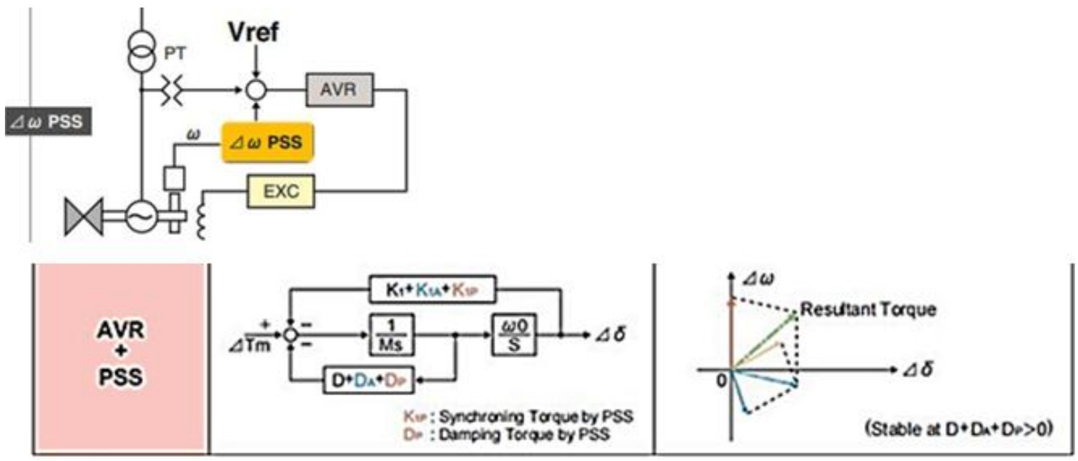

Figure 6. Model PSS in generation power system

1) Materials and Methods

The material used is electric equipment at the Lontar PLTU. Meanwhile, the method used is a simulation of the Transient Stability Analysis program at the ETAP Sub Station Lontar-Balaraja-Kembangan as the focus of the analysis where the feeder has the largest load compared to other feeders. In the system that has been described in the ETAP, load termination or load switching is simulated in the balaraja-throw-development sub-system.

2) Data to be simulated

The data needed in this simulation is the data in the Lontar PLTU, namely:

The generator used for transient stability analysis in the 20kV Lontar system is a type of generator with the use of Steam or PLTU as many as 4 units with a capacity of 315 MW each, a voltage of 20 kV and a rotor speed of 3000 rpm.

Step Up Transformer, capacity 370 MVA, 20 kV/150 kV, 3 P, 50 Hz.

Step down transformer capacity 40 MVA, 20 kV/ 6 kV, 3P, 50 Hz

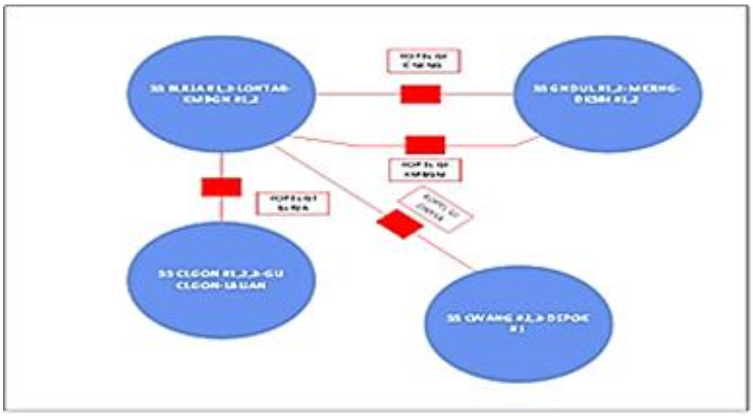

Figure 7. Operational flexibility of SS-Lontar-Balaraja 1.2-Lontar-Kembangan 1.2 Source: UP P2B JKB

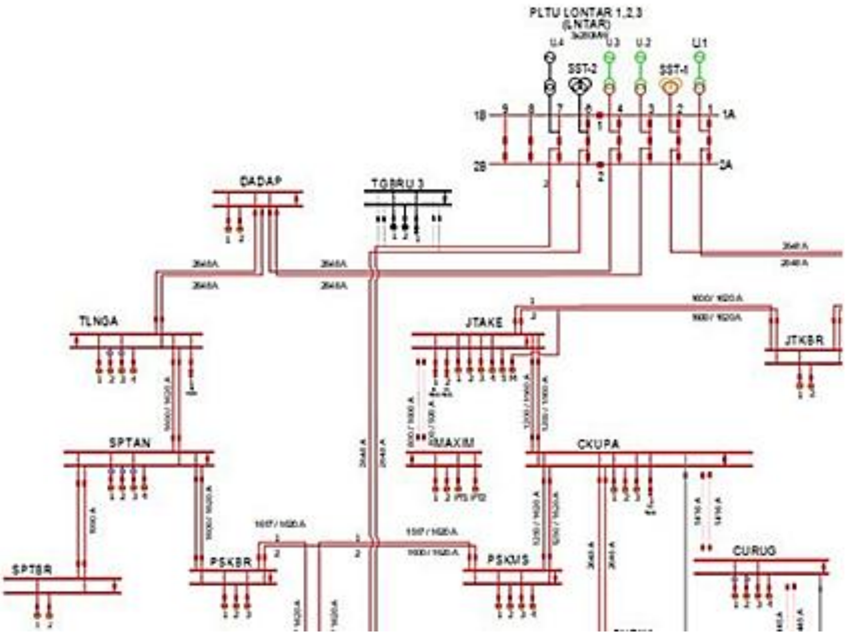

Figure 8. Single line diagram of the electricity system of PLTU Lontar

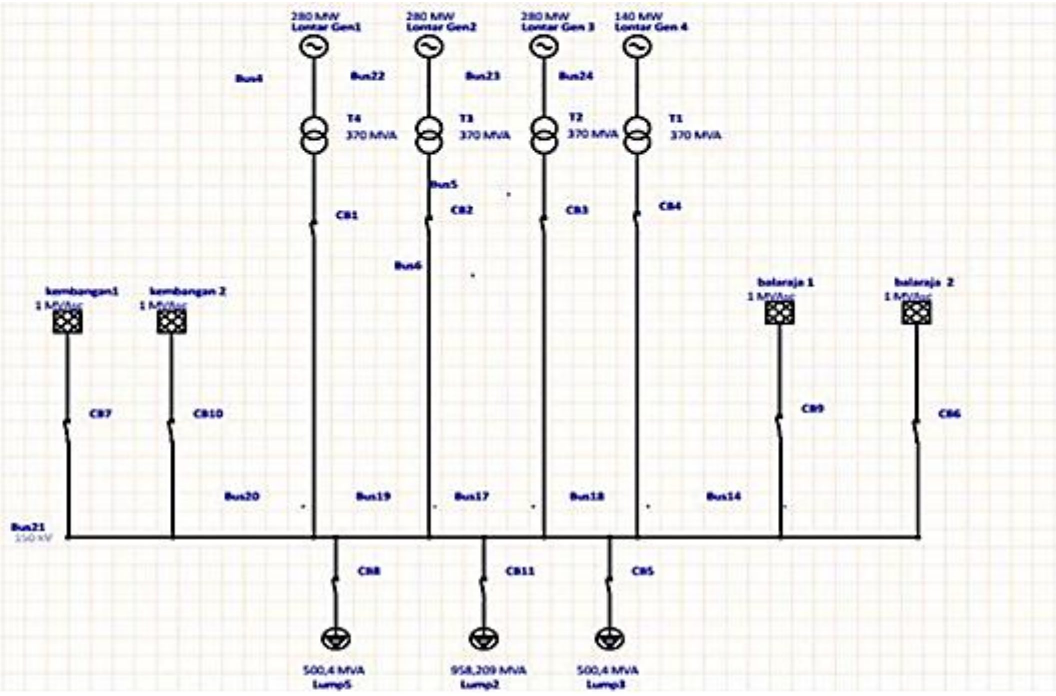

Figure 9. Single line SS Lontar-Kembangan-Balaraja network with ETAP POWER

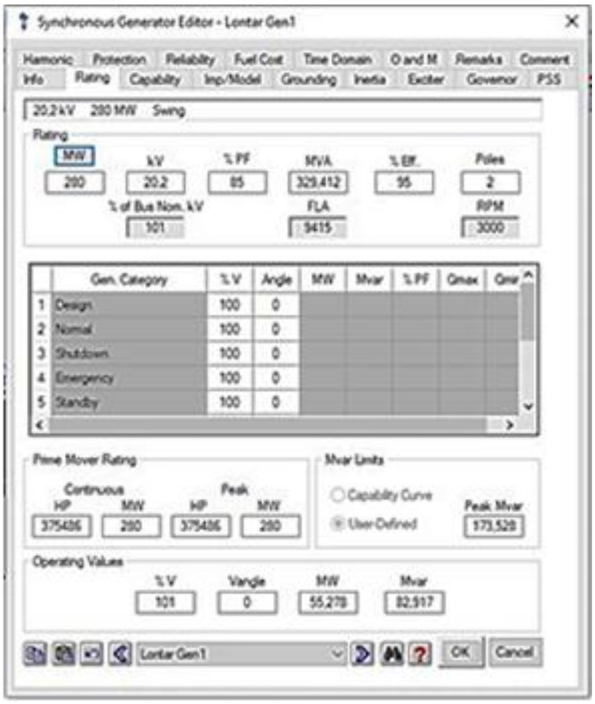

Figure 10. Data input according to the actual rating of the equipment

III. SIMULATION AND ANALYSIS

A. *Load Termination Simulation*

In carrying out the Transient Stability Analysis program at the ETAP Sub Station Lontar-Balaraja-Kembangan as the focus of the Analysis where the tray has the greatest load compared to other feeders. In the system that has been described in the ETAP, load termination or load switching is simulated in the balaraja-throw-development sub-system

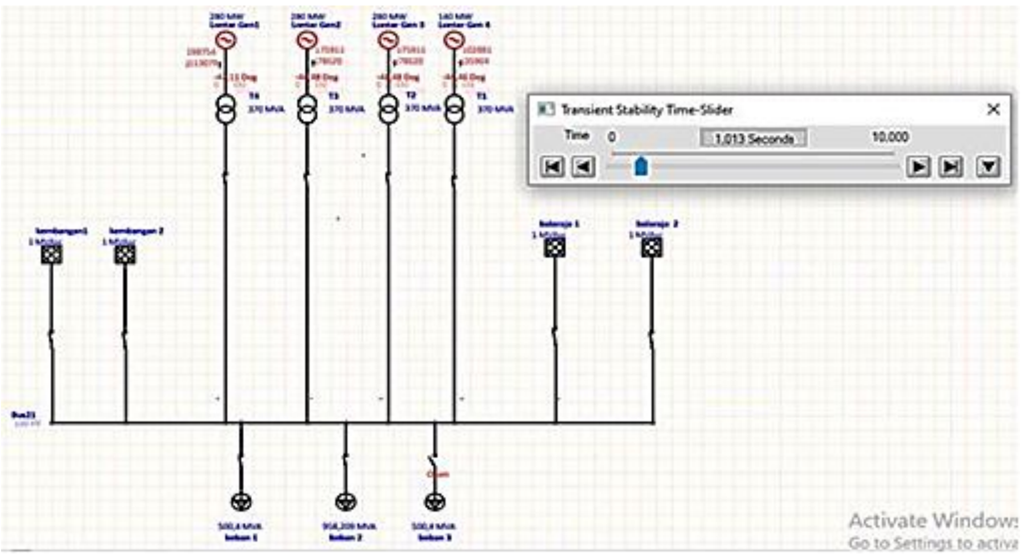

Figure 11. Cut-off time simulation load 500 MVA

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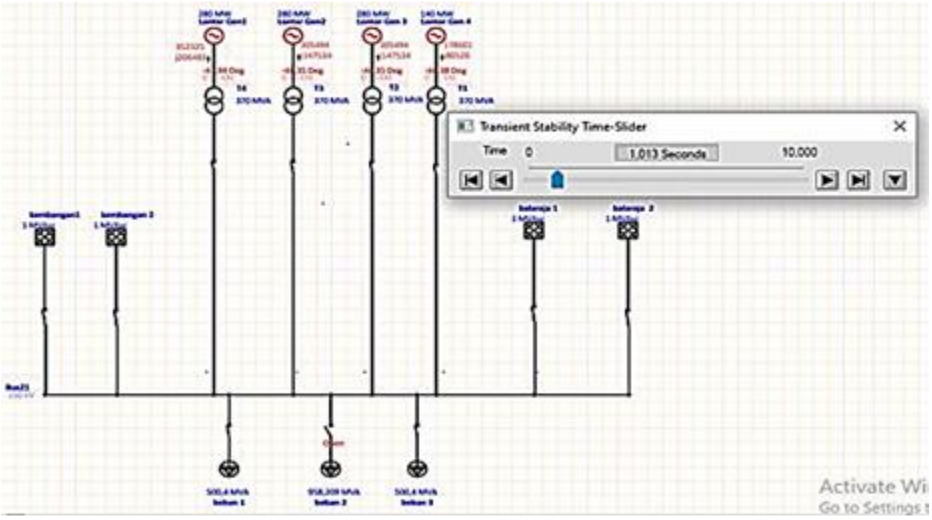

Figure 12. Termination simulation load 958 MVA

B. *Transient Stability Analysis prior to PSS installation*

Results of Simulation of Transient Stability Analysis on Load Switching:

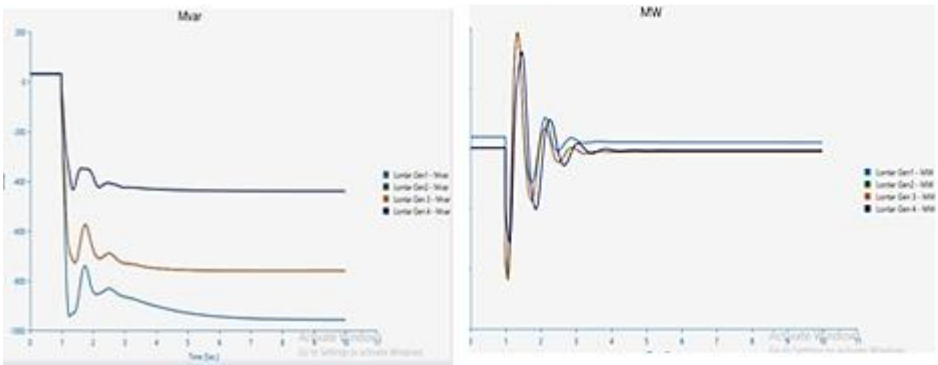

Figure 12. Transient stability at 500 MVA load termination

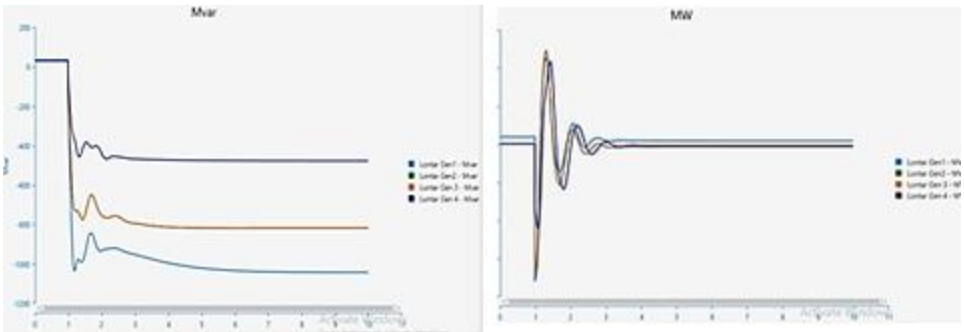

Figure 13. Transient speed at load breakage 958 MVA

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The image shows a change in power after the load is cut off and enters a switching state with an interval of 4 seconds, where the X axis shows the time (seconds) and the Y axis shows the amount of power, and the current.

The transient condition arises at the 1st second when the load is disconnected from the system and enters a steady state at the 4th second

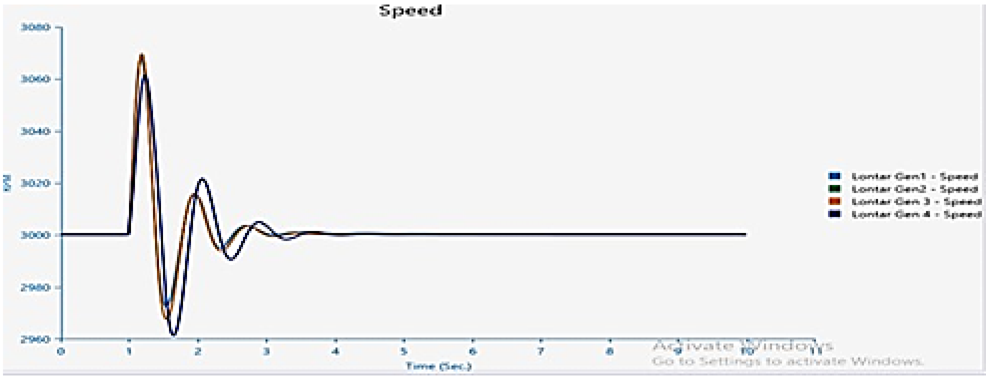

Figure 14. Transient speed at load breakage of 500 MVA

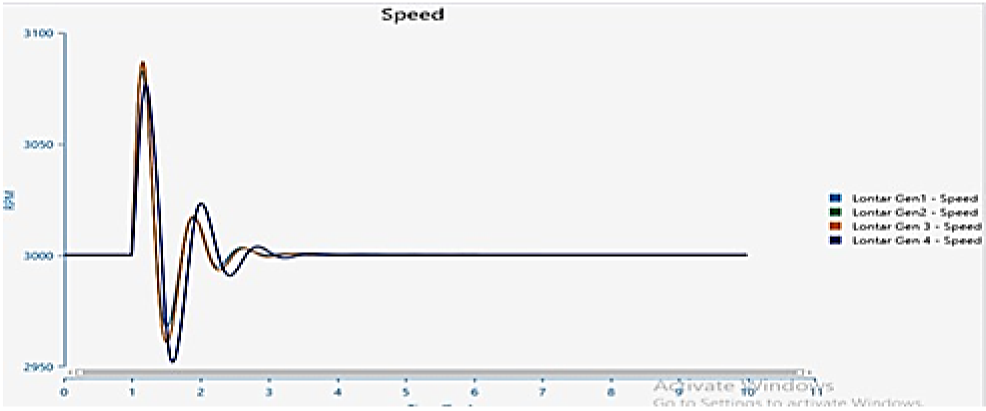

Figure 15. Transient speed at load breakage 958 MVA

For the Speed in the image above, it can be seen that the generator has experienced a surge of up to 3070 rpm which is equivalent to 51.2 Hz in frequency and in 0.5 seconds drops to 2960 rpm which is equivalent to 49.3 Hz and starts to stabilize again in 4 seconds.

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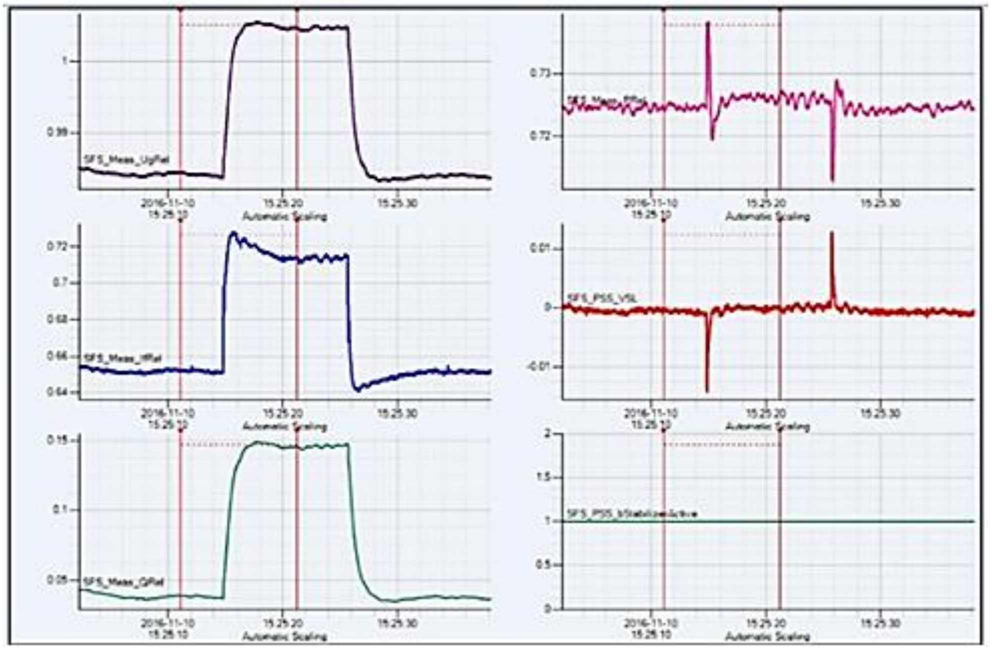

Figure 16. Generator parameter response when PSS ON

In the image, it can be observed that the wave in pink shows the active power of the generator, and the red wave is the response of PSS to intervene in excitation. When there is a fluctuation due to interference, the PSS will try to stabilize the generator parameters by giving commands that are opposite to the generator's reaction when responding to network fluctuations with response times down to the microsecond level.

VI. Conclusions

With the use of the Power System Stabilizer, it can be seen that PSS can increase transient stability in the 150 kV system of Teluk Naga Tangerang. The increase can be seen from the change of fluctuating waves to more stable when PSS ON, changes include:

1) The voltage response before PSS ON is up to 20.17 kV, while when PSS ON is only around 20.01 kV
2) The active power response is not yet in the range of 5 MW, when PSS ON is only at 1 MW
3) The frequency, which previously fluctuated at 50.02 Hz, drops to 50.01 Hz when PSS ON

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