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Analysis of induced voltage impacts of the Southern Sulawesi power system with integration of industrial load and wind power plant

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Abstract. Lightning strikes are one of the main causes of power outages that can result in dangerous conditions because of the high lightning strike current that may damage the electrical equipment. This study investigated the transient voltage of the Southern Sulawesi electricity system by considering the integration of 150 kV substations of Sengkang LNG and one wind power plant. Because of the integration plan, therefore it is necessary to analyse the impact of lightning strikes since it changes the network's structure. This research will simulate lightning strikes by modelling and analysing fluctuations during interference.

1. Introduction

At this time, the need for electrical energy is increasing in line with the development of new technologies. This must be followed by improvement in the electrical energy system, which must have high quality and reliability [1]. One of the ways that can be done to meet the increase of electricity needs is construction of renewable energy based generating plants [2], i.e. wind power plant, including in the Southern Sulawesi power system. The detail of the Southern Sulawesi power system can be seen in [3–5].

Liquefied Natural Gas (LNG) is natural gas that has been processed to eliminate its impurities and hydrocarbons then condensed into a liquid in pressure atmosphere by cooling it at a temperature of -160°C. PT. South Sulawesi LNG is one of the companies that engaged in the field of exploration of LNG. To meet their needs of electricity, PT. South Sulawesi LNG needs to construct new generating power plant. However, considering the time and the study for the design is quite long as well as the necessary cost of investment is quite large, then other alternative that can be done to meet their electricity needs is by building new 150 kV main substation connected to the Southern Sulawesi power system. By the addition of this new large load connected to a new 150 kV main substation then the required additional electricity supply is also large that certainly will have significant impact to the grid. The addition of this new load and substation will also affect the protection system. Therefore, it is important to assess the performance of the arrester during a strike after the integration of this new substation. Furthermore, it is necessary to perform an impulse stress analysis after the integration of the 150 kV Sengkang LNG substation into the Southern Sulawesi electricity system. Protection against lightning strikes can be done by placing a lightning rod transmission line to avoid the potential for



instability and load release [6]. In this study, the lightning strikes on the 150kV transmission line will be analyzed by looking at the condition of the voltage over time when interference occurs.

2. Methods

The simulation is done by assuming a lightning strike occurs at a high 150 kV transmission line between Sengkang substation and Sengkang LNG substation at the Southern Sulawesi power system after the integration of Sidrap Wind Power Plant and new Sengkang LNG substation.

Arresters as lightning rod function provides protection for the transmission equipment and electrical [7–9] during strikes. Arrester at transmission lines works by limiting the over voltage to avoid damage to the protected equipment [10,11]. There are two models of arrester, namely the Fernandez model and the Pinceti and Giannettoni models [12]. Another protective device used for protection from lightning on system power is Metal Oxide Varistor (MOV). MOV is usually used for the medium and high voltage system. In the simulation, MOV is modelled based on the IEEE WG 3.4.11. Fig. 1 shows the circuit for equivalent model of arresters that simplified by Pinceti et.al. which represent two non-linear resistors with RL filter [13].

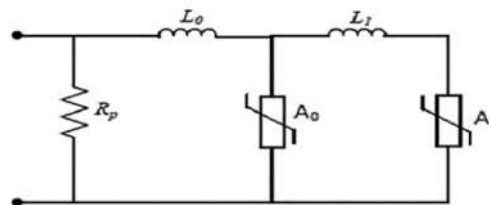


Figure 1. Pinceti's equivalent arrester model [14].

3. Results and discussion

This study evaluates the Southern Sulawesi power system performance when a lightning strikes occurs at a high 150 kV transmission line between Sengkang substation and Sengkang LNG substation at the Southern Sulawesi power system after the integration of Sidrap Wind Power Plant and new Sengkang LNG substation. The simulations were done by assuming 3 conditions:

3.1. Without arrester

Disruption of lightning strikes is assumed to happen at the 150 kV transmission line where no arrester on the system to observe the ability of the system to return to the condition of normal.

3.2. Using conventional arresters

The arrester used is assumed to be conventional arrester when lightning strikes happen at the 150 kV transmission line.

3.3. Using Pinceti arresters model

The arrester used is assumed to be Pinceti model arrester when lightning strikes happen at the 150 kV transmission line. Figs. 2 – 4 and table 1 shows the results of induced voltage for the 3 assumptions. Fig. 2 shows the induced lightning strikes voltage when a lightning strike happen at the 150 kV transmission line without arrester. As can be seen from Fig. 2, the induced voltage reaches up to 11 MV and it needs approximately 0.8 seconds to return to the normal operating voltage. Whereas Fig. 3 informs the induced lightning strikes voltage when a lightning strike happen at the 150 kV transmission line with conventional arrester. The induced voltage also reaches 11 MV, which does not give any significant improvement compare to without arrester, however, the time needed to return to its operating condition reduced to only 0.5 seconds. Fig. 4 informs the induced lightning strikes voltage when a lightning strike happen at the 150 kV transmission line with Pinceti arrester. It is

interesting that with Pinceti arrester model, the induced voltage can be reduced to 700 kV and the time to return to its normal operating voltage is only 0.1 seconds. Therefore, it is recommended to use the Pinceti arrester model for the Southern Sulawesi power system after the integration of Sidrap Wind Power Plant and new Sengkang LNG substation.

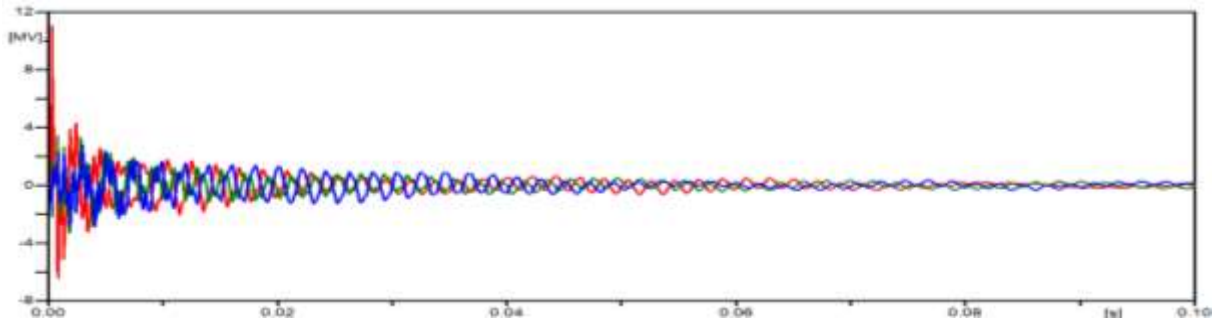


Figure 2. Induced lightning strikes voltage simulation without arrester.

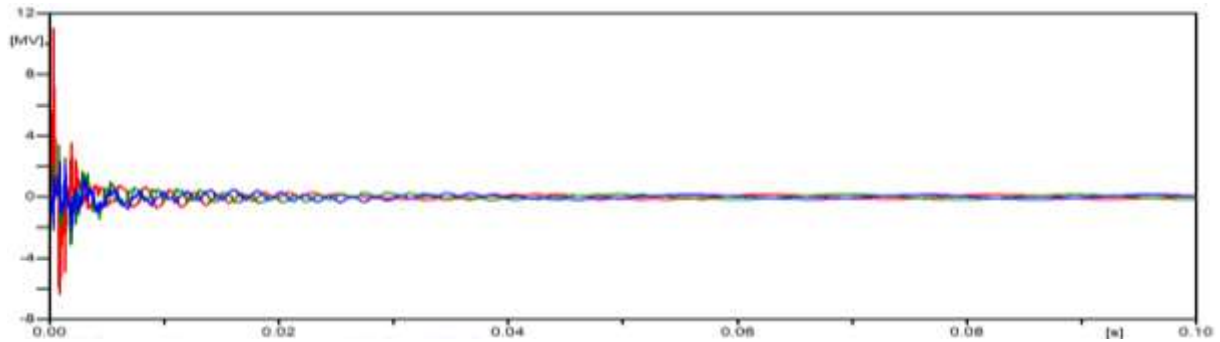


Figure 3. Induced lightning strikes voltage simulation with conventional arrester.

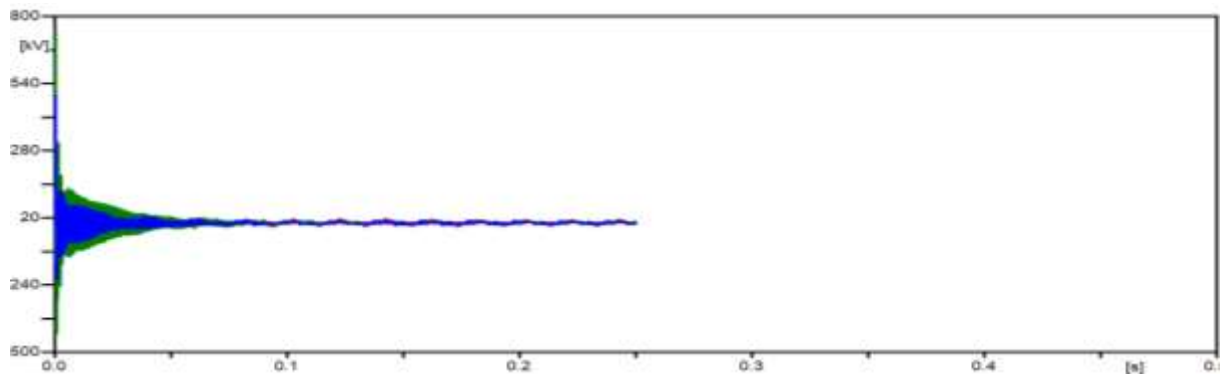


Figure 4. Induced lightning strikes voltage simulation with Pinceti's arrester model.

Table 1 Simulation results.

Simulation	Time	Induced Voltage
Without Arrester	0.8 s	11 MV
Conventional Arrester	0.5 s	11 MV
Pinceti Arrester Model	0.1 s	700 kV

4. Conclusion

This study evaluates the Southern Sulawesi power system performance when a lightning strikes occurs at a high 150 kV transmission line between Sengkang substation and Sengkang LNG substation at the Southern Sulawesi power system after the integration of Sidrap Wind Power Plant and new Sengkang LNG substation. The simulations were done by assuming 3 conditions: without arrester; using conventional arresters and using Pinceti arresters model. The simulation results shows that without arrester and by using conventional arrester, the induced voltage because of the strikes reaches to 11 MV, whereas with Pinceti arrester model, the induced voltage is only 700 kV and the time to return to its normal operating voltage is only 0.1 seconds. Therefore, it is recommended to use the Pinceti arrester model for the Southern Sulawesi power system after the integration of of Sidrap Wind Power Plant and new Sengkang LNG substation.

Acknowledgments

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