Alternative Improving the Quality of Sub-Voltage Transmission System using Static Var Compensator

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Abstract. This study discusses the voltage profile improvement method in the transmission sub-systems using one of the devices from Flexible Alternating Current Transmission Systems (FACTS), by using a Static Var Compensator (SVC) with the object focused on electric power system sub-systems in South Bandung area and Ujung Berung. The aims of the study were to determine the voltage profile sub-systems in South Bandung and Ujung Berung before and after installation of SVC and also to determine the position and capacity of SVC in maintaining optimal voltage profile transmission sub-system. The research method used the power flow simulation from Newton-Raphson method with ETAP 7.0. The flow of reactive power had been set so that the power loss on the network (losses) system obtained a minimum. The results of the simulation and power flow analysis shows that the average voltage profile and quality of installation SVC voltage sub-systems after the optimal position and capacity to be better compared to prior to installation. By minimizing the power loss on the network, the bus voltage profile can be maintained in the values that are allowed, so the quality and continuity of operation in the power system can be maintained.

1. Introduction

In the electric power system, the voltage change mainly caused by varying loads and network topology changes. Shrinkage stress can be great or even it occurs *voltage collapse* when the network is operating at heavy loads.[1] When a large voltage shrinkage, it can make the impact to the voltage at the receiving end to be small, and it can result in poor performance of electrical equipment and make them to have a possible damage. Meanwhile, when the *collapse voltage* enables operation of *under-voltage relays* and other protection systems, in a state of disconnection of electrical power to the load will result in a loss to the consumer. Other conditions such as low load levels will result in *over-voltage* which will result in *capacitive over-compensation capacitive* and *over-excitation* on the machine simultaneously.[2]

The FACTS *(Flexible Alternating Current Transmission System)* Technology suggested by Narian G. Hingorani of the *Electrical Power Research Institute* (EPRI) is one of the cutting edge reactive power compensator that can be applied to the network, and one of the main devices that becomes the most significant element in FACTS is SVC *(Static Var Compensator).* SVC is used to keep the voltage profile remain on the required limits when it is connected to the rail weak by injecting current.[3] *Static Var Compensator* is a generator and / or absorbent in which statically connected in parallel which has output varied to control some parameters in the power system. The term *static* is used to indicate that the SVC is not as *synchronous compensators,* which has no rotating parts. An SVC consists of a *static var generator* (SVG) or *absorber device*.[4] Identification on rails that have been attributed to SVC has been done with power flow analysis.

This research will simulate power flow in the network of Subsystems Transmission Region II West Java after the installation of SVC to improve voltage profile at high load conditions. This study was done on Subsystems Transmission Region II West Java Subsystems in South Bandung and Subsystems of Ujungberung because in these subsystems occur shrinkage stress relatively high over the authorized limit voltage rating issued by the IEEE for 0.95 until 1:05 p.u.

2. Method

The study was conducted by field data collection based on the continuity of service conditions of the electrical energy supplied to consumers. PT PLN Sub Distribution has complete responsibility for the quality of electrical power supply, both in terms of quantity and quality. Research steps performed by a series of procedures as follows (See Figure 1):

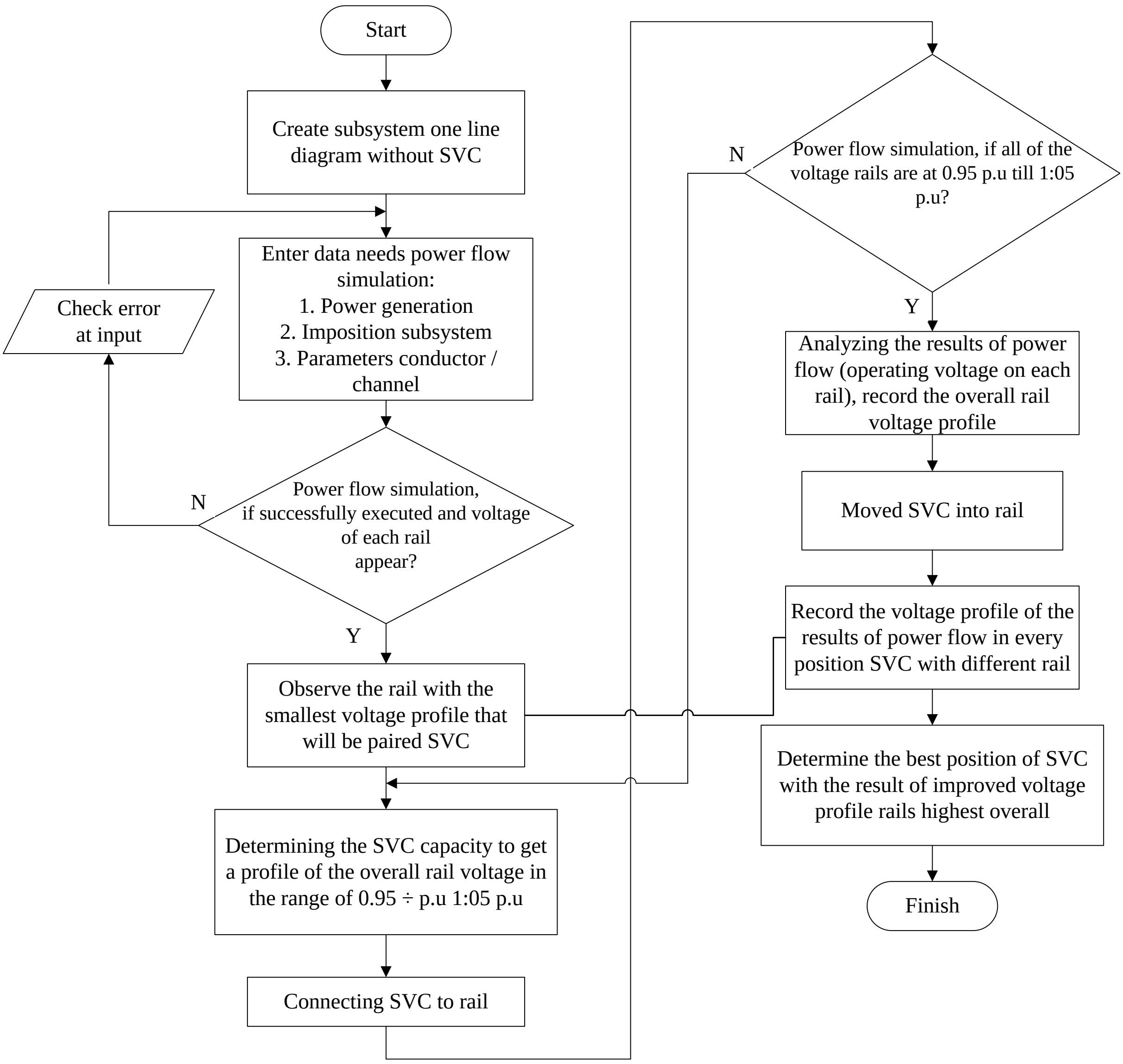

Figure 1. Flowchart of the Research

This study refers to the roadmap of Scientific Affairs Group (KBK) Power System transmission network system that is the constellation of power system power flow from upstream to downstream. Research on electric power transmission has been developed since 2012 by the Group of Scientific Field of Electrical Power Systems, Department of Electrical Engineering Education, FPTK UPI. The final goal of this research plan is the creation of a comprehensive assessment of the reliability and stability of the models system for the electric power transmission system in the area II P3B PLN West Java.

The preliminary study on system power transmission system network was initiated by conducting a study of the methods of standard. The method has been done by the CBC Electricity System DPTE FPTK UPI, by including an improved model voltage, modelling and simulation and computational algorithms intelligent voltage profile improvement. The results of these studies have been and will be implemented in lectures conducted in Electricity Transmission System in the Department of Electrical Engineering Education FPTK UPI.

3. Result and Discussion

3.1 Voltage Rail Subsystem South Bandung and New Ujungberung before Installation SVC

Profile rail voltage recorded by PT. PLN (Persero) is a voltage profile read directly by the SCADA system *(Supervisory, Control, and Data Acquisition)*, while the voltage profile rails at 7.0 ETAP simulation results obtained from the power flow. Simulation of power flow in ETAP 7.0 can be done when all the input parameters as mentioned in Chapter 3 has been incorporated. The case studies of power flow in ETAP 7.0, there are three methods, the first one is the Newton-Raphson, Fast-decoupled, and Accelerated Gauss-Seidel.

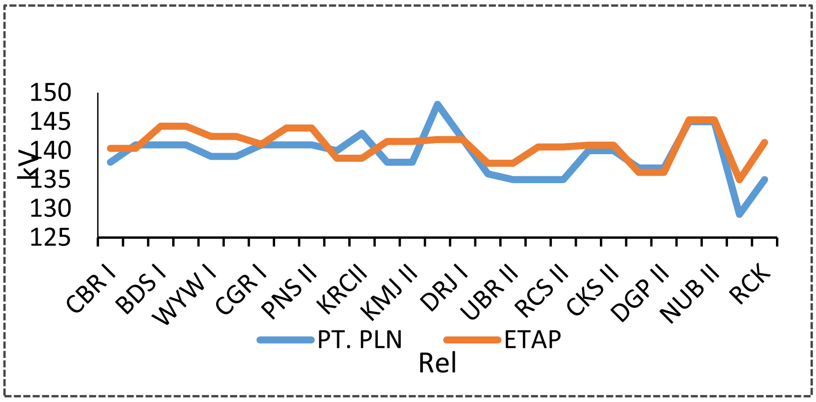

Figure 2. Graph readings voltage profile by PT. PLN and 7.0 ETAP program.

On Figure 2, it shows that there is an error or difference in voltage profile readings read by the SCADA system of PT. PLN (Persero) and ETAP 7.0 with the error value that varies from the smallest error found on the reading voltage profile rail Darajat I is 0:06% or 0:08 kV and the sharpest error reading of voltage profile rail Rancaekek by 4.76% or by 5:42 kV with average of overall error voltage profile readout amounted 3:14% of reading by SCADA systems PT. PLN (Persero).

3.2 Voltage Rail Subsystem South Bandung and New Ujungberung after Installation SVC B

The voltage profile obtained on ETAP 7.0 is the result from the simulation of power flow using the Newton-Raphson with the maximum iteration used is 1000 iterations, because the amount of maximum iteration on the value of the simulation of power flow can be executed when the subsystem South Bandung and New Ujungberung associated with SVC at -250 MVAr rating and +300 MVAr in North Bandung rail I as a rail with the smallest voltage profile, and precision is 0.0001.

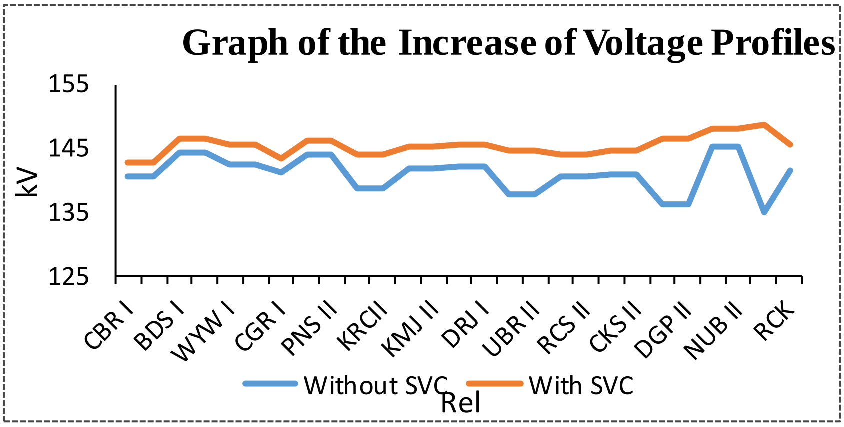

Figure 3. Graph of the increase of voltage profiles before and after installation SVC

Figure 3 shows the increase in the profile rail voltage that varies from the smallest voltage increase to the most. The increase in smallest voltage profiles occur on the rail South Bandung I and II on the increase in the voltage of 2,086 kV or 1:45% from 144.22 kV to 146.3, while the increase in greatest voltage profiles on the rail in North Bandung I has a total number approximately 13 673 kV or 10:13% from 134.97 kV to 148.64 kV, making it the overall voltage profile rail subsystems contained in South Bandung and New Ujungberung increased, with the average increase of $ 3.10 kV.

3.3 Determining the Location and the Capacity of SVC in Maintaining Profile Voltage at 0.95 p.u. range until 1:05 pu

In determining the optimal SVC capacity to maintain the overall profile rail voltage is at about 0.95 p.u. until 1:05 p.u., the SVC is connected to the rails of North Bandung I as a rail with the smallest voltage profile for the starting position, optimal capacity for the SVC is equal to -250 Mvar to the capacity of the value of the reactive power from the capacitors; and 300 Mvar for reactive power capacity of the reactor (-250 Mvar and 300 Mvar). The SVC capacity values were obtained in the experiments of the 12th, because at trial from the 1st through the 11th did not find a suitable SVC capacity. A stage of experimentation to determine the capacity or the SVC rating listed on trial to-1 to 11 is:

-50 Mvar and 75 Mvar.
-75 Mvar and 100 Mvar.
-125 Mvar and 150 Mvar.
-150 Mvar and 200 Mvar.
-175 Mvar and 200 Mvar.

-200 Mvar and 250 Mvar.
-215 Mvar and 250 Mvar.
-220 Mvar and 250 Mvar.
-225 Mvar and 300 Mvar.
-235 Mvar and 300 Mvar.
-245 Mvar and 300 Mvar.

SVC capacity in the range of -250 Mvar and 300 Mvar is the smallest capacity in maintaining overall voltage rail profiles are in the range 0.95 p.u. until 1:05 p.u., with the smallest voltage profile contained on rail Cibereum I and II with a value of 0.95 p.u. because the capacity range slightly below 12th trial, on trial for-11 with a capacity in the range of -245 and 300 MVAr, there is still a voltage profile rail 0.9499 pu or at 142 483 kV is on the rail Cibereum I and II, and the value of the voltage profile little below 0.95. Note of the overall value profile rail voltage at SVC capacity optimization of experiments to-1 to 12 shown in table 4.4, but for more detail information can be seen in the appendix.

After getting the optimal capacity of SVC in maintaining the voltage profile in the range 0.95 p.u. to 1:05 p.u. with a value of -250 Mvar capacity and 300 Mvar placed on rails Bandung Utara I, now SVC with such capacity will be paired on the other rail one by one with readings of the voltage profile of the power flow on ETAP 7.0.

4. Conclusion

The transmission system of 150 kV in the region II of South Bandung, West Java subsystem and New Ujungberung has the overall profile rail voltage is low, the voltage profile readout by SCADA systems PT. PLN (Persero) there are 23 rail profiles have voltages below 0.95 p.u., whereas the power flow simulations at the ETAP 7.0 there are 21 tracks. By combining *Static Var Compensator* (SVC) systems, SVC can improve voltage profile rails as a whole in the range of 0.95 p.u. until 1:05 p.u, the smallest voltage profile rail amounted to 142.53 kV on the rail Cibereum I and II while the greatest profile rail voltage of 148.64 kV in North Bandung rail I. Position and the most optimal SVC capacity in maintaining the overall profile rail voltage in the range 0.95 p.u. to 1:05 p.u. is when the installation of SVC in North Bandung rail -250 Mvar I with a capacity of up to 300 Mvar.

References

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