Implementation of the Static Var Compensator (SVC) in the sub system 150 KV transmission to improvement effort voltage quality in West Java Area

H Hasbullah*, Y Mulyadi, W S Saputra and N Muhammad
Universitas Pendidikan Indonesia, Bandung, Indonesia

*hasbullah-elektro@upi.edu

Abstract. This study aims to determine the voltage losses on the 150 KV transmission line in Cibatu and Mandirancan Sub-systems in the PLN APB West Java region. This study utilizes the effect of the installation of Static VAR Compensator on voltage losses on a 150 KV transmission line during peak load conditions. By knowing the characteristics of the system on a channel that utilizes sensitivity to the addition of loads, the installation of SVC will have an impact on the improvement of voltage losses on the transmission network. This study uses simulations using ETAP software version 12.6. From the calculation simulation results that use the actual data of APB West Java in the amount of voltage loss on the channel. While based on the ETAP simulation results, there were improvements in voltage losses at Dawuan substation by 13.56%. This proves that SVC installation on transmission lines can reduce voltage losses in the Cibatu and Mandirancan Sub Systems.

1. Introduction
Electric power systems have to work optimally in serving loads that are volatile and the type of load. The characteristics of the load greatly affect capacity and capability systems within transmit power. Network configuration of a vast and growing also causes the operation of electric power systems become complex and difficult to control.

In the planning and operation of electric power network stability system is an important aspect to be considered. Power system must be operated with the aim of maintaining the channel power and the voltage on each bus is at the limit of its operations. Change of reactive power is one of the causes is not stable voltage in the system. For example not stable voltage and loss-power loss in the transmission line. Loss-power loss on the larger system when the system is operating at maximum load. On the conditions of the system can be stabilised by means of injecting or abortion reactive-power condition, such as capacitor banks or equipment Flexible AC Transmission Systems (FACTS).

FACTS working flexibly and directly usable for reactive power transfer which is very helpful in the operation of electricity networks, performance power system can be improved by using the FACTS, one of which with Static VAR Compensator (SVC). SCV is one of the most effective device to increase the stability of the voltage and increase power transfer capability of transmission network. For it should be mounted in place of the SVC that is correct with the appropriate parameters.

The purpose of this research is to know the characteristics of a system, so as to know the bus that is sensitive to the addition of the load. From the bus SVC who later paired will correct the voltage profile and influence on improvement of loss-loss of voltage on transmission line.
2. Review of the literature

2.1. Electric power transmission

Electrical power from the plant channelled to various places via the transmission line. Voltage transmission line in the system is 150 PLN, the so-called kV the air channels high voltage (SUTT) and 275-500 kV called extra high voltage air channels (SUTET). In America used the start voltage 115kV to 756kV [1].

There is actually two possibility the construction of the transmission line that is above ground channels (overhead) we call air duct, and underground (underground). Air duct length is usually up to hundreds of kilometres. The conductor is a conductor used bare (without solid insulation) so he had to be supported by insulators mounted on a tower. The channel associated with the air in around so it is affected by natural conditions such as pollution and a lightning bolt. The transmission line must have the flexibility to channel major resources through a number of routes. It must be designed in such a way so that the failure of a small number the channel does not cause failure of the entire system. It also should be able to serve as a liaison that is able to channel the energy into two directions. Hardware that connects the generator and transmission line is a transformer, which serves to change the generator output voltage to a higher transmission voltage [1].

2.2. Power

Power is the energy expended to do business. In the electric power system, power is the amount of energy used to perform work or effort. Electrical power is usually expressed in units of Watts or Horsepower (HP). Horsepower is a unit of electrical power which 1 HP 746 Watts or equivalent lbft/second. While the Watt is a unit of electrical power which 1 watt has power equivalent to the power produced by the multiplication of flow 1 Ampere and voltage of 1 Volt [2].

There are three types of electrical power, i.e. [2]:

Active power (Active Power) is used to perform the actual energy. The units of the active power is the Watt. For example heat energy, light, mechanical and others--other.

\[ P = 3 \sqrt{V_p^2 L_p^2 \cos \phi} \]  \hspace{1cm} (1)

Reactive power is the amount of power required for the formation of a magnetic field. From the formation of the magnetic field then the magnetic field flux will be formed. An example of the power that creates reactive power is a transformer, motors, incandescent lamps and other – other. Reactive power unit is the Var.

\[ Q = 3 \sqrt{V_p^2 L_p^2 \sin \phi} \]  \hspace{1cm} (2)

Pseudo power (Apparent Power) is the power generated by the multiplication between voltage and current rms within a network or power that is the result.

\[ S = 3 \sqrt{V_p L_p} \]  \hspace{1cm} (3)

The summation of trigonometric power active and reactive power. Pseudo power units are VA.

2.3. Power factor

Power factor is the ratio between active power P (in watts) with total power S (Volt Ampere) or cosines angle between the active power and the total. High reactive power will improve this corner and as a result the power factor will be lower.
2.4. Transmission distance short

The transmission line is the medium used to transmit electrical power from the generator station/power station until the distribution station up to consumer users of electricity [3]. To complete the function as part of a system of electric power distribution, transmission line has 4 parameters namely reactance, inductance, capacitance and conductance [4].

Transmission line physically has the length that stretched as far as tens or hundreds of kilometres. As a result, the resistance, inductance and capacitance relating to transmission line also distributed along the channel. There are three transmission line modelling based on distance i.e. modelling of transmission line short-haul, medium, and long.

In short distance transmission line modelling capacitance can be ignored without resulting in the existence of many mistakes if the channel is less than 80 km (50 MI), or if the voltage is not more than 69kV. Short distance channel model is the result of the multiplication of series impedance per unit from the overall line length [5].

\[ z = (r + j\omega L) l = R + jX \]  \hspace{1cm} (4)

Where r and L in a row is resistance per phase and the inductance per unit length and is the line length. The basic model of short-haul channels per phase Vs and Is the phase of the voltage and current is transmitted on the channel, and VR and IR is the phase of the voltage and current on either end of the receiver channels.

If a load of 3 phase power with a pseudo SR (3 Φ) is connected on the other end of the transmission line, then the accepted current expressed as follows:

\[ I = \frac{S}{R (3 bores must)/3V} \]  \hspace{1cm} (5)

The phase of the voltage on the sender side is

\[ VS = VR + ZIR \]  \hspace{1cm} (6)

Because of the parallel capacitance is negligible, then the current that is transmitted to the end and received at the other end is

\[ IS = IR \]  \hspace{1cm} (7)

2.5. Flexible Alternating Current Transmission Systems (FACTS)

FACTS is a merger of the power-electronic and the controller, which is used to increase the value of a network transmission by increasing the use of its capacity. With rapid control operations, the FACTS raise the limit for safe operation at the transmission system without disturbing the stability of the system. Where there are 3 types of FACTS that is, parallel, series and series-parallel [6]. On controlling FACTS using equipment solid-state electrical switching. Growing use of the FACTS then the system that controlled ever growing.

2.6. Static Var Compensator (SVC)

SVC is part of a system of flexible transmission AIR CONDITIONING equipment, voltage regulator and stabilize the system, and is one of the many FACTS devices used and installed in parallel against the bus. SVC has the ability to generate or absorb reactive power [7].

SVC will compensate for the reactive power distribution network by means of injecting or absorbing reactive power, appropriate conditions [8]. The term static is based on the fact that at a time
when operating or make changes to compensation no moving part of the SVC, setting the magnitude of VAR and voltage is done by setting the magnitude of inductive reactive power compensation on the reactor.

If the system load is capacitive reactive power or leading, SVC will raise the power reactor to reduce the voltage from the system so that the VAR system down. On the inductive reactive conditions or lagging, the SVC will reduce power reactor to raise the VAR of the system so that the system voltage will rise.

![Figure 2. SVC as acceptance variables.](image)

(a) The series FC-TCR, (b) Model SVC [9].

The basic structure of SVC shown in Figure 2 which shows that the model of SVC is represented by the fixed capacitors and reactors under control. Through a suitable coordination of capacitor and reactor for reactive power bus, injected or absorbed by the SVC can be continuously varied to control the voltage or to maintain the desired power flow in the transmission network through normal operation or in the condition of the interference [7].

2.7. The ETAP (Electrical Transient Analyzer Program) ETAP is the software used to do modelling/planning and an overview of the existing electrical system in an industry or region power plant. So with ETAP could he did test the power system at a power plant that has been designed in the ETAP software. This software is very useful to perform various analyses and ETAP easily edit graphics one line diagram.

![Figure 3. The main view ETAP 12.6.0.](image)

3. Methods

3.1. Flow research Systematic workflows in research must be observed. It is useful to give direction and facilitate understanding and goals to be achieved in the process of research. The research of flow shown in the flowchart below research.
3.2. Power flow simulation using ETAP 12.6.0.

Power flow simulation run to get the power flow on the sub system 3-4 and Cibatu Mandirancan with voltage of 150kV. Process simulation is performed with two power alira State, i.e. the State of the system before the SVC is installed and the State system of having installed SVC. Then the results of the simulations will be analysed based on the Voltage State of the results of the simulator with the State of the rill from the results of the installation the SVC.

3.3. Determine the position and capacity of SVC

In determining the position of a typical seating of SVC on the power flow simulation system 3-4 and Cibatu sub Mandirancan 150 kV using ETAP 12.6.0 is with how to pair the parent booths at SVC value loss-the greatest voltage loss or who have the value of loss-loss more than 15 kV voltage from a voltage of 150 kV or should correspond to the value of that 1995 SPLN voltage range the lowest was 135 kV or loss-loss value 15 kV voltage of 150 kV rating should be.

After mounting the SVC on a troubled parent booths, and voltage value changes, those changes will affect the voltage loss loss changes, then in accordance with predetermined capacity, the SVC move on stem other booths which then results the changes recorded value per booth.
After the specified position then the next step is to replace the value of the SVC with the capacity and then paired back on a troubled parent booths. Then, after mounting the SVC on May 23, 2017 at 18.00 do analysis determination of placement SVC at the most optimal parent booths.

Based on the flowchart attached research under SVC installation steps on the system are as follows:

- Make a line diagram of the sub system IBT Cibatu 3-4 and Mandirancan 150 kV at ETAP 12.6.0
- Place the technical data electrical data covering sember, the imposition of sub system and conducting data input as a parameter on a system diagram a line sub system Cibatu IBT 3-4 and Mandirancan.
- Run the simulation whether flow had power, can running, and observe the results of the voltage of the system that had been in the running.
- Attach the SVC on parent booths that have a loss-the biggest with a capacity of voltage loss vary and do a running stream of power.
- Checking whether there is a change in loss-loss of voltage.
- After getting the big change data loss – loss of voltage, then do the installation SVC turns on the entire substation.
- Record the results change loss-loss voltage in each channel and determine the most optimal position of the SVC.
- Compare and analyse the major changes to loss-power loss from simulated results ETAP 12.6.0 before and after couple SVC in sub Cibatu IBT system 3-4 dan Mandirancan.
- Finish

4. Results and discussion

Once the process of data collection is done in the form of data-parameter data along with a component in the diagram one line Sub Cibatu system IBT 3-4 and mandirancan further voltage profile data and parameters taken from the settings Area of the load (APB) Java section the middle of the data is based on a reading of the Supervisory, Control and Data Aquisiton (SCADA). On this reading of the voltage profile will be done by using the simulator ETAP 12.6.0. Then this data is simulated on the ETAP 12.6.0 with one line diagram illustrates the sub system 3-4 and mandirancan IBT Cibatu and pasting data parameters on the components described previously. After getting the results of simulation data in the form of voltage profile using ETAP 12.6.0 calculated data so obtained data loss-loss of voltage. On the simulator ETAP 12.6.0 there are 3 methods of settlement of load flow analysis, i.e. with the Newton-Raphson method, Fast-Decoupl, and Gauss-Seide. Research on settlement Load flow analysis method that is used is the Newton-Raphson, because these methods more efficient and practical for large systems. As for the results of the simulations that have run sub discussed on the next chapter.

4.1. Loss-loss voltage in sub system 3-4 and mandirancan IBT Cibatu before mounting Static Var Compensator (SVC)

Voltage loss loss on each rail on sub Cibatu IBT system 3-4 and mandirancang on May 23, 2017 at 18.00 GMT which will be discussed in this research is data loss loss voltage in a can from the results of the counting loss loss voltage with the data profile the voltage is obtained from PT. PLN (PERSERO) Area load settings (APB) and data on the ETAP 12.6.0. Loss-loss of voltage is shown in table 1.
Table 1. Loss loss voltage Rails on the sub system IBT Cibatu 3-4 and PT Mandirancan PLN (PERSERO) and ETAP 12.6.0.

| No | Sub System    | SCADA(kV) | ETAP(kV) | Error |
|----|---------------|-----------|----------|-------|
| 1  | Cibatu        | 5         | 6,427    | 0.984 |
| 2  | Mekarsari     | 8.6       | 10,567   | 1.391 |
| 3  | Pinayungan    | 11.86     | 12,49    | 0.456 |
| 4  | Tegalherang   | 11        | 12,603   | 1.153 |
| 5  | pruri         | 12.71     | 13,706   | 0.725 |
| 6  | Parungmulya   | 13.46     | 14,231   | 0.564 |
| 7  | Teluk Jambe   | 14.45     | 14,372   | 0.057 |
| 8  | Honda         | 13.46     | 14,278   | 0.599 |
| 9  | Maligi        | 13.63     | 14,284   | 0.479 |
| 10 | Kiarapayung   | 12.2      | 14,331   | 1.546 |
| 11 | Kutamekar     | 12.5      | 14,896   | 1.742 |
| 12 | Kosambi Baru  | 14        | 14,21    | 0.154 |
| 13 | Dawuan        | 16.81     | 15,369   | 1.081 |
| 14 | Tatajabatr    | 14.03     | 11,938   | 1.515 |
| 15 | jatiluhur     | 13        | 10,281   | 1.946 |
| 16 | Indramayu     | 1.32      | 2,278    | 0.648 |
| 17 | sukamandi     | 6.7       | 4.64     | 1.417 |
| 18 | Haurgeulis    | 6.44      | 5.45     | 0.684 |
| 19 | Cikedung      | 5.9       | 5.381    | 0.358 |
| 20 | Mandirancan   | 6.48      | 1.769    | 3.178 |
| 21 | Jatibaran     | 6.87      | 4.536    | 1.604 |
| 22 | Suryaragi     | 4.29      | 2.567    | 1.168 |

Table 1 shows the data loss-loss voltage in railroad that operated in kilo-Volt (kV) that is read by the SCADA system PT. PLN (PERSERO) and at ETAP 12.6.0 after completion of power flow simulation has started. Loss loss voltage in railroad are read either from PT. PLN (PERSERO) as well as from a reading of the ETAP 12.6.0 value loss-loss voltage varies. The greatest voltage loss loss read by SCADA system PT. PLN (PERSERO) is a railway in the parent value Dawuan substation loss-loss voltage of 16.81 kV whereas the results of the simulation application SUITE 12.6.0 on parent booths have the same loss-loss voltage of 15.369 kV with a value of error of 1.081%. Loss-the smallest loss read by SCADA system PT. PLN (PERSERO) is present on the stem with a value of Indramayu substation loss voltage of 1.32 kV while on the results of the simulation application SUITE 12.6.0 on parent booths have the same loss-loss of 2.278 voltage with a value of error of 0.648%.
Figure 5. Comparison chart-loss loss voltage by PT. PLN (PERSERO) and ETAP 12.6.0.

From the above figure 5, image errors or differences of readout loss-loss voltage read by the SCADA system PT. PLN (PERSERO) and ETAP 12.6.0 error value varies, from the most minor error value is present on the holding of a new substation Kosambi 0.154% or amounting to 0.21 kV and the biggest error is present on the parent mandirancan substation of 3.178% or of 4.711 kV with an average overall error in the reading of the voltage loss loss amounted to 1.066% or amounting to 1.599 kV from the reading by the SCADA system PT. PLN (PERSERO). Error in ETAP because not all of the components in the input into the simulation and components at the ETAP are considered new.

4.2. Loss loss voltage in sub Cibatu system IBT 3-4 and Mandirancan after the installation of a Static Var Compensator (SVC)

At this time the sub chapter will be discussed regarding loss-loss voltage in sub Cibatu IBT 3-4 150 kV system on May 23, 2017 at 18.00 BST se5telah installation SVC on ETAP 12.6.0 program as it has been in the know in the previous chapter that the results in the get voltage at ETAP 12.6.0 is the result of power flow analysis using Newton-Raphson method with 1000 iterations, maximum iterations and precision value of 0.0001. Due to the value of the number of iterations and the value of the precision, simulation can run when power flow Sub Cibatu system IBT3-4 and Mandirancan associated with the SVC is on rating-199 MVAR and + 199 MVAR. In its deliberations on this chapter of the sub will be discussed regarding the influence of the use of SVC in increasing the value of the operating voltage profile on each parent booths on sub-district 3-4 IBT Cibatu system and Mandirancan 150 kV.
Table 2. Comparison of voltage loss before and after mounting the SVC on sub system Cibatu IBT 3-4 and Mandirancan.

| No | Sub System     | Before | After | Deviation |
|----|----------------|--------|-------|-----------|
| 1  | Cibatu         | 6,427  | 6,182 | 0,245     |
| 2  | Mekarsari      | 10,567 | 10,172| 0,395     |
| 3  | Pinayungan     | 12,49  | 12,022| 0,468     |
| 4  | Tegalherang    | 12,603 | 12,131| 0,472     |
| 5  | pruri          | 13,706 | 13,158| 0,548     |
| 6  | Parungmulya    | 14,231 | 13,62  | 0,611     |
| 7  | Teluk Jambe    | 14,372 | 13,759| 0,613     |
| 8  | Honda          | 14,278 | 13,667| 0,611     |
| 9  | Malig    | 14,284 | 13,61  | 0,674     |
| 10 | Kiarpayung    | 14,331 | 13,656| 0,675     |
| 11 | Kutamekar      | 14,896 | 14,189| 0,707     |
| 12 | Kosambi Baru  | 14,21  | 13,565| 0,645     |
| 13 | Dawuan         | 15,369 | 14,263| 1,106     |
| 14 | Tatajabat      | 11,938 | 11,391| 0,547     |
| 15 | jatiluhur      | 10,281 | 9,801 | 0,48      |
| 16 | Indramayu      | 2,278  | 2,186 | 0,092     |
| 17 | sukamandi      | 4,64   | 4,567 | 0,073     |
| 18 | Haurgeulis     | 5,45   | 5,396 | 0,054     |
| 19 | Cikedung       | 5,381  | 5,338 | 0,043     |
| 20 | Mandirancan    | 1,769  | 1,763 | 0,006     |
| 21 | Jatibarang     | 4,536  | 4,507 | 0,029     |
| 22 | Suryaragi      | 2,567  | 2,563 | 0,004     |

Figure 6. Comparison chart value loss of voltage before and after mounting the SVC.
The data in table 2 and figure 6 shows the varying voltage loss improvement on substation parent starting from small improvements up to major improvements. Improvements to the smallest voltage loss exist in the parent post Suryaragi with improvements of 0.004 kV value before installation SVC of 1.563 kV and the value after installation SVC be 1.567 kV and fixes the most there is in substation Dawuan's parent with improvements of 1.106 kV value before installation SVC of 15.369 kV and the value after installation SVC of 14, 263kV. From the results of the rating value SVC pemsangan-50 and + 50 MVAR at parent Dawuan substation there is improvement of loss-loss voltage in sub system Cibatu IBT 3-4 and Mandirancan with the number of repair loss of 9.098 kV.

4.3. Determination of location and capacity in an attempt to repair the loss-loss of voltage on transmission systems 150 kV system in IBT3-4 and Cibatu Mandirancan

As it has been explained in Chapter 3 sub 3.7 chapter about how to determine the position and capacity or rating on the SVC on the ETAP programme 12.6.0 done by determining the initial position of the SVC on parent booths, have the greatest voltage loss loss values and determine his capacity to get the value of a loss-loss of voltage is not more than the voltage of 15kV supposed i.e. 150 kV in accordance with the 1995 SPLN range 135 kV to 157.5 kV.

In determining the optimal SVC capacity in an attempt to reduce voltage loss loss-SVC is connected on the Rails at the parent post Dawuan as parent booths that have the greatest voltage loss loss values for the position was beginning, the capacity used by the author to SVC is registration-199MVAR for capacity reactive power of the capacitor value and 199 MVAR reactive power from the reactor (-199 MVAR and 199MVAR) capacity value obtained from the SVC experiment results to actual 4-on the first try with a rating of SVC registration-50 MVAR and 50 MVAR was enough to make the system be on the voltage rating corresponds to 1995 SPLN, however the author try to the maximum capacity that can be run by ETAP 12.6.0 with maximum number of iterations and 1000 value precision 0.0001 author a bold experiment 4 times with details as follows:

- 50 and 50 MVAR
- -100 MVAR and 100 MVAR
- -150 150 and MVAR
- -199 MVAR and 199 MVAR

As previously mentioned installation SVC value rating – 50 50 MVAR and already happening-loss voltage repair and profile voltage is in compliance with the 1995 SPLN in vulnerable 135 kV to 157.5 kV with voltage loss loss-value the smallest is present on the parent mandirancan substation with voltage loss loss-value of 1.763 kV and the largest loss loss value is present on the parent value Dawuan substation loss loss voltage of 14.263 kV.

Table 3. Number of loss loss voltage on all substations parent Sub System IBT Cibatu 34 and Mandirancan.

| No | Sub System      | Experiment 1 | Experiment 2 | Experiment 3 | Experiment 4 |
|----|-----------------|--------------|--------------|--------------|--------------|
| 1  | Cibatu          | 218,581      | 216,948      | 215,256      | 213,697      |
| 2  | Mekarsari       | 215,951      | 211,934      | 207,447      | 203,916      |
| 3  | Pinayungan      | 214,297      | 210,527      | 203,222      | 198,446      |
| 4  | Tegalherang     | 214,246      | 208,394      | 203,121      | 138,398      |
| 5  | Pruri           | 213,012      | 206,563      | 199,889      | 194,225      |
| 6  | Parungmulya     | 211,956      | 204,801      | 197,523      | 191,686      |
| 7  | Teluk Jambe     | 212,536      | 204,624      | 198,042      | 191,565      |
| 8  | Honda           | 212,288      | 204,714      | 198,223      | 191,052      |
| 9  | Maligi          | 215,201      | 204,553      | 197,577      | 191,509      |
| 10 | Kiarpayung      | 212,107      | 204,546      | 197,713      | 193,482      |
| 11 | Kutamekar       | 211,71       | 204,042      | 200,369      | 191,616      |
In the specify the location of the placement SVC in an attempt to reduce voltage loss loss-done installation SVC with a capacity in accordance with the results of the determination of the calculation of reactive power injection in the system. Mounting the SVC conducted done by pairing the SVC on the Rails in a troubled parent booths (the rail has a value of voltage loss loss above 15 kV suit SPLN)

As mentioned on the previous sub chapter 4.1.3 for that matter at the time of installation SVC of 50MVAR and 50 MVAR all parent booths were in accordance with the standards of the SPLN range 135 to 157.5 kV voltage-loss or loss does not exceed with 15kV voltage loss-loss-the biggest being at booths Dawuan's parent with the value loss loss of voltage of 15.389 kV as for loss-loss voltage smallest how parent booths at mandirancan with the value loss loss of voltage of 1.705 kV

When viewed in table 4.5 when SVC is mounted on a 50 rating-MVAR and repair damages happening MVAR 50-loss voltage in sub Cibatu system IBT 3-4 and Mandirancan. Improvement of voltage loss-loss the best there is on the parent Dawuan booths with improvements lose power loss of voltage of 9.098 kV voltage loss before the SVC in pairs of 220.604 kV and after in pairs while being 211.506 kV SVC repair loss-loss the smallest voltage is present on the parent Suryaragi substation with voltage improvement of voltage loss loss kV from 0.047 previously of 220.604 kV and after installed into 220.557 kV.

On experiment by pasting a value rating on SVC of-100 MVAR and 100 MVAR occurs repair damages happening voltage loss. Improvement of voltage loss-loss of the greatest voltage still on the parent value Dawuan substation improvement of loss-loss of voltage 29.903 kV of loss loss voltage before installation SVC of 220.604 kV and after the install of 220.224 kV SVC.

On experiment installation SVC with rating-150 150 and MVAR, repair damages happening significant improvements to the voltage loss-loss of the largest voltage still on the parent value Dawuan substation improvement of loss-loss of voltage 29.903 kV of loss loss voltage before installation SVC of 220.604 kV and after mounting the SVC loss-loss voltage be 190.701 kV. For the

| No | Sub System   | Experiment 1 | Experiment 2 | Experiment 3 | Experiment 4 |
|----|--------------|--------------|--------------|--------------|--------------|
| 12 | Kosambi Baru | 212,301      | 204,748      | 197,848      | 191,738      |
| 13 | Dawuan      | 211,506      | 203,452      | 196,641      | 190,701      |
| 14 | Tatajabar   | 214,246      | 208,987      | 204,162      | 201,139      |
| 15 | Jatiluhur   | 215,744      | 211,478      | 207,709      | 204,705      |
| 16 | Indramayu   | 220,954      | 220,311      | 220,082      | 219,837      |
| 17 | Sukamandi   | 219,331      | 218,726      | 217,085      | 207,342      |
| 18 | Haurgeulis  | 219,852      | 216,7        | 216,333      | 214,683      |
| 19 | Cikedung    | 218,837      | 217,398      | 216,21       | 215,232      |
| 20 | Mandirancan | 220,455      | 220,311      | 220,082      | 219,837      |
| 21 | Jatibarang  | 219,398      | 218,052      | 217,645      | 216,679      |
| 22 | Suryaragi   | 220,557      | 220,224      | 219,913      | 218,279      |
repair of damages to the smallest there is voltage-loss at the parent post Mandirancan with a value of voltage-loss-repair of 0.767 kV of voltage-loss loss before SVC installation of 220.604 kV and after mounting the SVC-loss loss voltage become a 219.873 kV.

Loss loss voltage in sub system Cibatu IBT3-4 and Mandirancan seen from the amount of the value loss-loss voltage in each parent booths, each booth has a parent value of the voltage-loss loss variant be but the author operates on improvement loss-loss voltage in sub system Cibatu IBT3-4 and Mandirancan. From the results of the simulation in optimum installation get that SVC is present on the stem Dawuan booths because the value of the most significant improvements in system of 29.903 kV voltage loss loss or improvement of 13.56%

In the calculation of the manual on the SVC based on data P = 1300.836 MW 394.794 dang MVAR then corresponds to the formula (2.3) the value of all the load power is 1359.412 MVA, so they have a power factor of a load of 0.96.

Then thus so that the presence of power factor improvement required reactive power injection with original power factor of 0.95 and the desired power factor 0.99 IE so that based on the formula (2.4) as follows

\[ 0.317 \text{ rad} = 16, 260 \]
\[ \text{and rad} = 0.142 8.1 \text{o} \]
then
\[ \text{MVAR 196.42} \]

So in experiments using reactive power injection SVC of 199 MVAR, because not too far from capacity calculation above and also the value is the value of the maximum capacity of the SVC can be fitted and do the iteration by ETAP 12.6.0.

When viewed in outline based on simulation results, show that the SVC can fix loss-loss of voltage on the system effectively, SVC is placed as close as possible with the load, as for the reason for the placement of injecting reactive power should be as close as possible to the point of requiring additional power and placement SVC at the point load is preferred due to the effect of repair of loss-the loss of her most high voltage

5. Conclusion

5.1. Conclusion

Referring to the findings and discussion in the previous chapter, there are several conclusions that can be taken. As for the summary is as follows:

- Loss loss voltage before installation of Static VAR Compensator in Sub 3-4 and IBT Cibatu System Mandirancan on reading by the SCADA system PT. PLN (PERSERO) of 224.71 kV and on simulations of ETAP 12.6.0 of 220.604 kV with an error in the reading of the SCADA system PT. PLN (PERSERO) and simulation result ETAP 12.6.0 amounted to 1.066%
- loss of voltage after the installation of a Static VAR Compensator using simulated ETAP 12.6.0 on the first try with a rating of 50-50 and MVAR loss loss voltage on sub system 3-4 and IBT Cibatu Madirancan be 211.506 kV or no improvement of 9.098 kV, in a second experiment with rating-100 MVAR and 100 MVAR loss loss voltage in sub system 3-4 and IBT Cibatu Madirancan be 203.425 kV or no improvement of 17.152 kV, in a third experiment with rating-150 150 and MVAR loss-loss the voltage on the sub system 3-4 and IBT Cibatu Madirancan be 196.641 kV or no improvement of 23.963 kV and the fourth experiment with the value of the rating-199 199 MVAR and loss-loss voltage in sub system 3-4 and IBT Cibatu Madirancan be 190.701 kV or is there an improvement of 29.903 kV
- refer to the results of research in the previous chapter that the optimal placement of the installation Static VAR Compensator in the Sub 3-4 Mandirancan IBT Cibatu System is present on the mains Substation Dawuan with improvement of loss-loss of voltage 29.903 kV or amounted to 13.56%
5.2. Implications and recommendations
Based on the results of the research that has been done can be found implication and recommendations as follows:

- The results of the study prove that the existence of injecting the appropriate reactive power SVC can improve significantly against the loss – loss of voltage on the sub system Cibatu IBT 3-4 Mandirancan. This also showed the SVC has contributions that in an effort to reduce the huge loss-loss transmission line voltage on 150 kV Sub Cibatu system IBT3-4 and Mandirancan.

- Results of the research can be expected in consideration for PT. PLN (PERSERO) for using SVC at 150 kV transmission network in an attempt to reduce loss-loss of voltage. But in this case required consideration between the maximum load capacity on the channel capacity and transmission introduction injecting reactive power SVC so hopefully can avoid excess load on the transmission line.

- in conducting further research is expected on process simulation using the latest version of ETAP and library to conduction that is used must comply with the conditions of real parameters and overall on the SVC can be known so that the results obtained are becoming more accurate and done on sub system to another.

- Further improvement concerning the profile of the voltage on the transmission subsystem uses a Static Var Compensator (SVC) is expected to involve a whole part of the system so that power flow simulation results with greater precision the actual situation e.g. in transmission system subsystem Cibatu and Mandirancan there are also part of the system with a voltage rating of 70 kV.

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