# A Voltage Improvement of Transmission System using Static Var Compensator via Matlab/Simulink

**Article** *in* Indonesian Journal of Electrical Engineering and Computer Science · May 2017

DOI: 10.11591/ijeecs.v6.i2.pp330-337



Professor Dr. Ismail Musirin
Universiti Teknologi MARA

**Indonesian Journal of Electrical Engineering and Computer Science**
Vol. 6, No. 2, May 2017, pp. 330 ~ 337
DOI: 10.11591/ijeecs.v6.i2.pp330-337


# A Voltage Improvement of Transmission System Using Static Var Compensator Via Matlab/Simulink

**Siti Amely Jumaat*[1], Ismail Musirin[2], Mazliya Mohd Baharun[3]**
[1,3]Faculty of Electrical and Electronics Engineering, Universiti Tun Hussein Onn Malaysia (UTHM), 86400 Batu Pahat, Johor, Malaysia
[2]Universiti Teknologi MARA (UiTM), Malaysia, 40450 Shah Alam, Selangor, Malaysia
*Corresponding author, e-mail: sitiamely1979@gmail.com

***Abstract***

*High demand in electricity consumption is rising and modern society would case to function without access to electricity. The volume of power transmitted and distributed are increasing, these need the requirements for high quality and reliable supply. At the same time, rising the costs and the growing environmental concerns make the process of develop a new power transmission line make complicated and the time consuming. One of alternatives to solve the issues is installed the Flexible AC Transmission System (FACTS). This research presents to modeling and simulation of Static Var Compensator (SVC) in the power system network using Matlab/Simulink Software. The objective function of this research is improvement the voltage of the system with four cases study for validation. From the simulation results shown that the SVC installation gives the effect to voltage of system.*

***Keywords**: Static Var Compensator, Voltage Improvement, Matlab/Simulink, Transmission System*



## 1. Introduction

The electric power system has grown in size and complexity with a huge number of interconnections to meet the increase in the electric power demand. Moreover, the role of long distance and large power transmission lines become more important. Due to this today's changing electric power systems create a growing need for flexibility, reliability, fast response and accuracy in the fields of electric power generation, transmission, distribution and consumption. Voltage instability is one of the phenomena which have result in a major blackout. Moreover, with the fast development of restructuring, the problem of voltage stability has become a major concern in deregulated power systems. To maintain security of such systems, it is desirable to plan suitable measures to improve power system security and increase voltage stability margins. Flexible Alternating Current Transmission Systems (FACTS) are new devices emanating from recent innovative technologies that are capable of altering voltage, phase angle and /or impedance at particular points in power systems. Static Var Compensators (SVC) devices are used to improve voltage and reactive power conditions in AC Systems. The effectiveness of this controller depends on its optimal location and proper signal selection in the power system network. SVC has the ability to improve stability by dynamically controlling it reactive power output. Hence, that SVC will successfully control the dynamic performance of power system and will effectively regulate the system oscillatory disturbances and voltage regulation of the power system.

In paper [1] Oyedoja *et al* presented the modelling and simulation study using in Matlab/Simulink with objective to resolve the voltage regulation and voltage stability problems. From the simulation result, can conclude modelling and simulation carried out confirmed that SVC could provide the fast acting voltage support necessary to prevent the possibility of voltage reduction and voltage collapse. In [2] using PSO and EP techniques to solve the objective function to minimize the loss when the load is subjected to Bus 26 and 30 of IEEE 30-Bus RTS. From the simulation results shows the impact in terms of loss reduction and voltage profile improvement. As conclusion, demonstrate that the proposed PSO technique is feasible for loss minimization scheme in other power system network. In [3] S.A. Jumaat *et al*, optimization techniques are PSO, EP and AIS applied when the load variations are subjected to buses 29 and 30 of IEEE 30 – Bus RTS for the minimization of active power loss. The objective is to

*Received January 8, 2017; Revised March 25, 2017; Accepted April 11, 2017*

minimization of active power loss in power system. From the simulation results can conclude, demonstrate that the proposed PSO technique is feasible for loss minimization scheme in other power system network. In [4], Amit Garg et. *al* proposed the model and simulation of SVC in MATLAB / Simulink Software with objective to maintain security of system, to improve and increase voltage stability margin. From that simulation results carried out confirm that SVC could provide the fast acting voltage support necessary to prevent the possibility of voltage reduction and voltage collapse. In [5] proposed the objective to improve and maintain the voltage regulation of the system using Matlab Software. From simulation result the installation of SVC at nearer to load side is the best methods to improve the voltage regulation. In [6] and [7] presented the modeling and simulation of the power system using PSCAD and MathCAD Software, respectively with objective to investigate the effects of SVC on voltage stability of the system. By simulation results shows the SVC can improve and maintain the voltage collapse, current and reactive power in the transmission line. In [8] proposed Newton-Raphson method to optimal placement of FACTS based on l-Index technique. In [9] presented a new method to finding the optimal location, size and number of Static Var Compensator in order to enhace the voltage stability of electrical network. The solution has been found by using the evolutionary programming algorithm, particle swarm optimization, combined with voltage stability indexes used for the estimation of the voltage collapse in power system.

This paper mainly focuses the improvement of voltage with the SVC installation into the power system network. The loads for the testing are in four cases: 10MW and 8MVar, 50MW and 10MVar, and 100MW and 15MVar and 150MW and 20MVar.

## 2. FACTS Devices

Flexible AC Transmission System (FACTS) controllers modify the series and parallel impedances of transmission lines. The way a FACTS controller is connected to the ac power system has a direct effect on the transfer of active and reactive power within the system. Series connected controllers are usually employed in active power control and to improve the transient stability of power systems. Shunt connected controllers govern reactive power and improve the dynamic stability [5].

Table 1 show the type and function of FACTS device. Static var compensators (SVC) control only one of the three important parameters (voltage, impedance, phase angle) that determine the power flow in the AC power system. It has been realized that SVC which is true equivalent of ideal synchronous condenser, is technically feasible with the use of gate turn – off (GTO) thyristor. The SSSC is a recently introduced FACTS controller which has the capability to control all the three transmission parameters (voltage, impedance, phase angle) [1]. The SSSC not only performs the functions of the STATCOM, TCSC, and the phase angle regulator but also provides additional flexibility by combining some of the functions of the controllers.

Table 1. Type and Function of Facts Device

| Name | Type | Main Function | Controller Used |
|---|---|---|---|
| SVC | Shunt | Voltage Control | Thyristor |
| STATCOM | Shunt | Voltage Control | GTO,IGBT or MCT |
| TCSC | Series | Power Flow Control | Thyristor |
| SSSC | Series | Voltage Control | GTO,IGBT or MCT |

### 2.1. Static Var Compensator (SVC)

Static Var Compensators (SVC) control only one of the three important parameters i.e voltage, impedance, and phase angle, that determine the power flow in the AC power system. It has been realized that SVC which is true equivalent of ideal synchronous condenser, is technically feasible with the use of gate turn–off (GTO) thyristor. The SSSC is a recently introduced FACTS controller which has the capability to control all the three transmission parameters (voltage, impedance, phase angle) [1]. The SSSC not only performs the functions of the STATCOM, TCSC, and the phase angle regulator but also provides additional flexibility by combining some of the functions of the controllers. The SVC regulates voltage at its terminal by controlling the amount of reactive power injected into or absorbed from the power system. When system voltage is low, the SVC generates reactive power (capacitive). When system voltage is high, it absorbs reactive power (inductive). The variation of reactive power is performed by switching three-phase capacitor banks and inductor banks connected on the secondary side of a coupling transformer. The SVC can be operated in two modes: in voltage regulation mode (the voltage is regulated within limits) and in VAR control mode (the SVC susceptance is kept constant). When the SVC is operated in voltage regulation mode, it implements the following V-I characteristics. As long as the SVC susceptance B stays within the maximum and minimum susceptance values imposed by the total reactive power of capacitor banks $Bc_{max}$ and reactor banks $Bl_{max}$, the voltage is regulated at the reference voltage Vref. However, a voltage droop is normally used usually between 1% and 4% at maximum reactive power output, and the V-I characteristic has the slope indicated in the Figure 1.

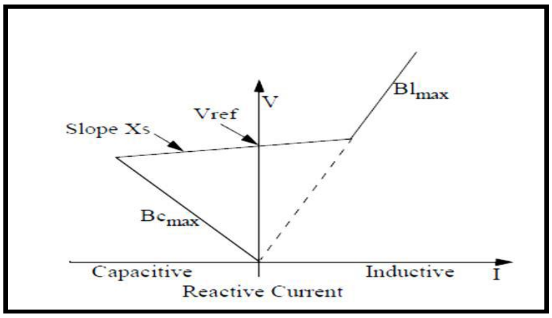


Figure 1. SVC V-I Characteristics

where
V = Positive sequence voltage p.u.
I = Reactive current (pu/phase) (I > 0 indicates an Inductive Current)
Xs = Slope or droop reactance (pu/phase)
$Bc_{max}$ = Maximum capacitive suspectance (pu/Phase) with all $TSC_s$ in service, no TSR or TCR.
$Bl_{max}$ = Maximum inductive suspectance (pu/Phase) with all $TSR_s$ in service, or TCRs at full conduction, no TSC.
Phase = Three – phase base power specified in the block diagram Box.

The steady-state and dynamic characteristics of SVCs describe the variation of SVC bus voltage with SVC current or reactive power, Figure 1 illustrates the terminal voltage-SVC current characteristic with specific slope.

$$Slope = \frac{\Delta V_{c\,max}}{I_{C\,max}} = \frac{\Delta V_{L\,max}}{I_{L\,max}} \tag{1}$$

The regulation slope allows:
1. To extend the linear operating range of the compensator
2. To improve the linear stability of the voltage regulation loop
3. To compensator as well as other voltage regulation devices.

The V – I characteristic is described by the following three equations:

$$V = V_{ref} + X_S * I \tag{2}$$

Where, SVC is in regulation range

$$B_{C\,max} < B > B_{L\,max}, V = \frac{I}{-B_{C\,max}} \tag{3}$$

Where, SVC is fully capacitive $B = B_{C\,max}$

$$V = \frac{I}{B_{L\,max}} \tag{4}$$

Where, SVC is fully inductive $B = B_{L\,max}$

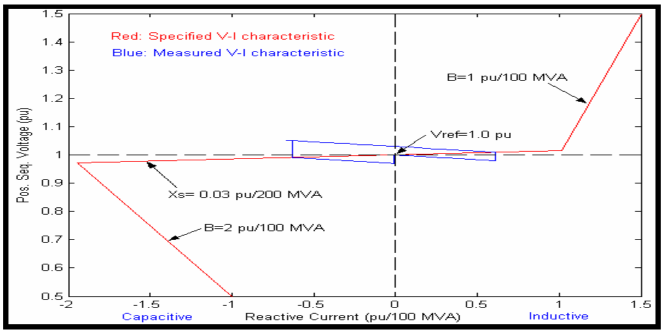


Figure 2. SVC Steady – state control characteristic

Location of an SVC strongly affects controllability of the swing modes. In general the best location is at a point where voltage swings are greatest. Normally, the mid – point of a transmission line between the two areas is a good candidate for placement. Tables and Figures are presented center, as shown below and cited in the manuscript.

## 3. Results and Analysis

This part presents a results obtained from MATLAB /Simulink software. The analysis and discussion of the results obtained from simulation are presented in this part. The testing for validation of the results is in two conditions: test system without and with SVC as shown in Figure 3 and 4, respectively. The voltage supply of test system is 3 phase system, 500kV, and transmission line is 30,000MVA, and X/R = 10. The characteristics of SVC model are shown in Figure 5 and 6, respectively where the power base, $P_{base}$ = 200,000VA, $Q_C$ =200,000Var and $Q_L$ =-200,000Var and time delay, $T_d$ = 4ms.

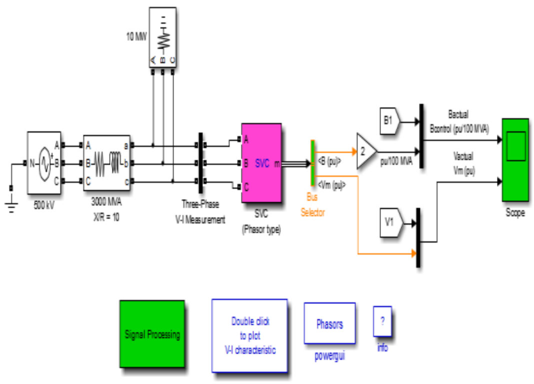

Figure 3. Test System without SVC

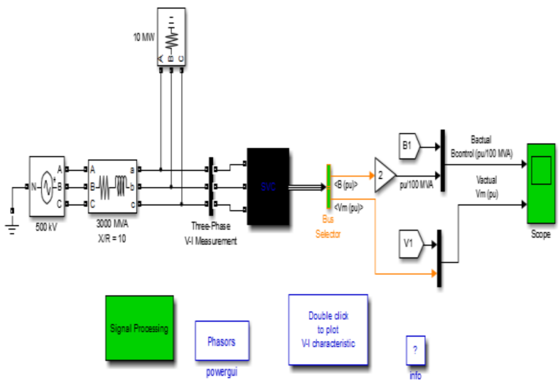

Figure 4. Test System with SVC

The loads of test system are setting by three phase series RLC load block diagram as shown in Figure 5. The loads for the testing are in four cases:

Case 1: 10MW and 8MVar
Case 2: 50MW and 10MVar
Case 3: 100MW and 15MVar
Case 4: 150MW and 20MVar

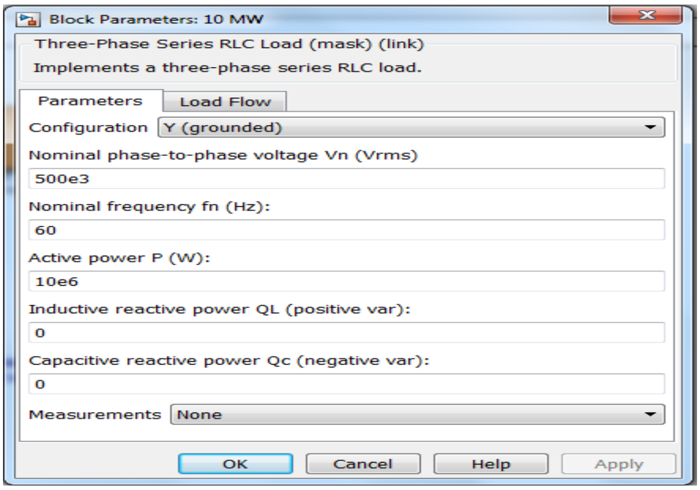


Figure 5. Block Parameter of Three Phase Series RLC Load

The results for without and with SVC for Case 1, Case 2, Case 3 and 4 as shown in Figure 6 to Figure 10, respectively.

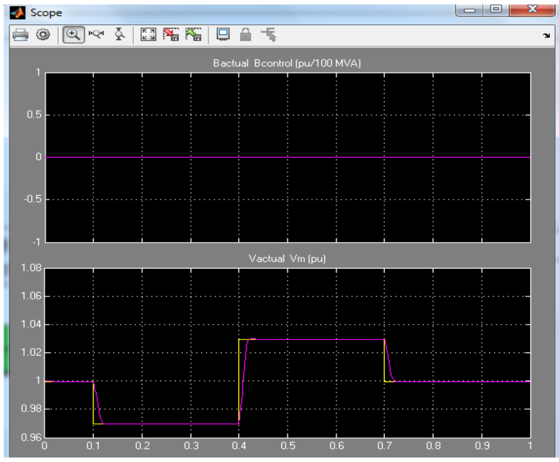


Figure 6. Results of voltage without SVC

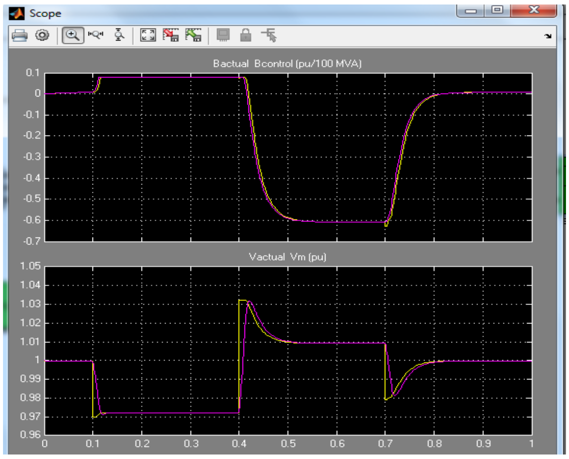


Figure 7. Results of voltage with SVC for Case 1

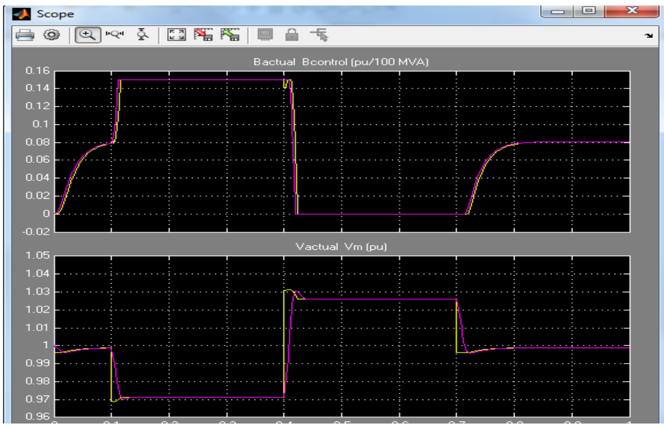


Figure 8. Results of voltage with SVC for Case 2

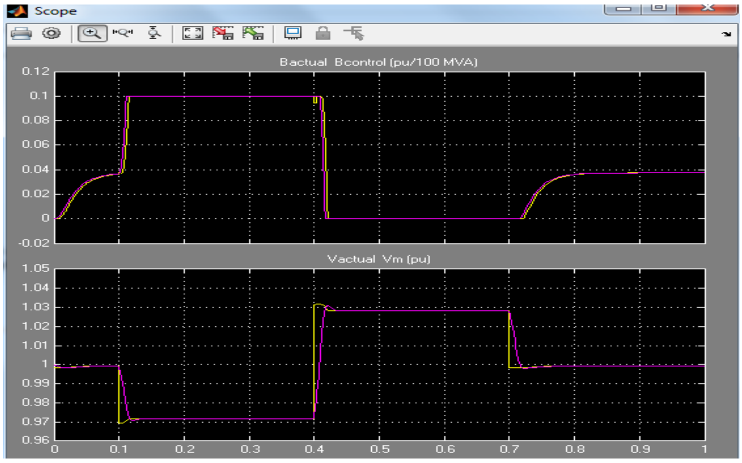


Figure 9. Results of voltage with SVC for Case 3

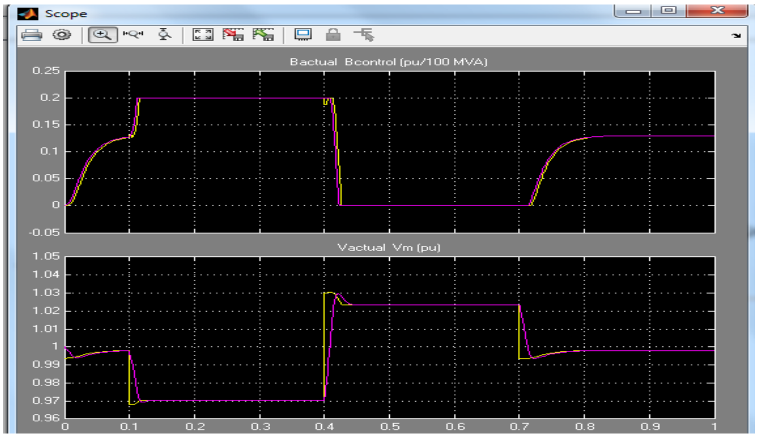


Figure 10. Results of voltage with SVC for Case 4

Table 2 is tabulated results of voltage improvement for Case 1, 2, 3 and 4. From Table 2 shows that when the load of the system is increased the voltage of system is decreased. Also, for instance, loads are 10MW and 8MVar, the voltage of system is 515.0kV. When the load is increased to 50MW and 10Mvar the voltage of system is 513.5kV.

On other hand, the installation of SVC in the system is improved the voltage of the system. For instance, the load of system are 10MW and 8MVar, the voltage is increase 516.5kV (0.29% improvement) from its original value i.e. 515kV. When the load of system is increase to 50MW and 10MVar, the voltage is increase 516.5kV (0.58% improvement) from its original value i.e. 513.5kV. Figure 11 shows the comparison of voltage with and without SVC installation. From the figure, the voltage of system is consistence to 515kV with SVC installation.

Table 2. Results of Voltage Improvement Using SVC

| Loads | | Voltage Result | | % imp. |
|---|---|---|---|---|
| | | Without SVC | With SVC | |
| MW | MVar | Volt (kV) | Volt (kV) | |
| 10 | 8 | 515.0 | 516.5 | 0.29 |
| 50 | 10 | 513.5 | 516.5 | 0.58 |
| 100 | 15 | 511.5 | 515.5 | 0.78 |
| 150 | 20 | 510.5 | 515.45 | 0.96 |

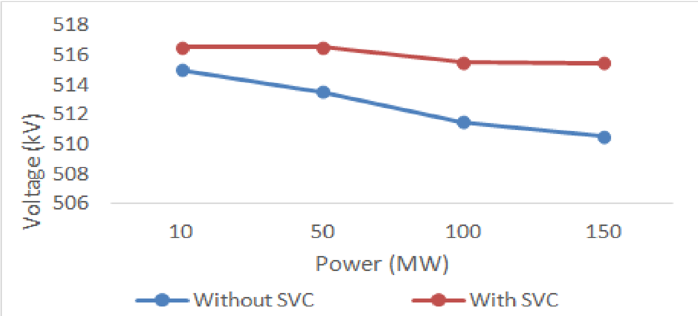


Figure 11. Comparison of Voltage With and Without SVC Installation

## 4. Conclusions

Generally, the objective of this research has been achieved. The voltage control devices which are SVC are successfully modeled in the MATLAB/ Simulink. SVC can be used for both inductive and capacitive compensation. When the voltage system is low the SVC generates the reactive power (SVC Capacitive).When the voltage system is high it is absorbs the reactive power (SVC Inductive). The results is obtained in the research has been analyzed and discussed. The comparison was done between four load conditions. These prove that the SVC model can be implemented on the transmission line systems, in order to protect the system from voltage collapse and voltage instability phenomenon.

## Acknowledgements

The authors would like to acknowledge The Institute of Research Management and Innovation (IRMI) UiTM, Shah Alam, Selangor, Malaysia and Ministry of Higher Education (MOHE) for the financial support of this research. This research is supported by MOHE under the Research Acculturation Grant Scheme (RAGS) with project code: 600-RMI/RAGS 5/3 (187/2014).

## References

[1] Oyedoja, Kayode. Oyeniyi. *Modelling and Simulation Study of the Use of Static VAR Compensator (SVC) for Voltage Control in Nigeria Transmission Network*. Department of Technical Education, Emmanuel Alayande Collage of Education, Oyo, Oyo State, Nigeria. 2014.
[2] SA Jumaat, I Musirin, MM Othman, H Moklis. Computational Intelligence Based Technique in Multiple FACTS Devices Installation for Power System Security. *Journal of Theoretical and Applied Information for Technology*. 2012.
[3] SA Jumaat, I Musirin, MM Othman, H Moklis. Comparison of FACTS Devices Installation in Power Transmission System. *International Review of Modelling and Simulations (I.R.E.M.O.S.)*. 2012.
[4] Amit Garg, Sanjai Kumar, Agarwal. Modelling and Simulation of Static Var Compensator for Improvement of Voltage Stability in Power System. *International Journal of Electronics Communication and Computer Engineering*. 2011.
[5] S Ravi Kumar, B Ramoji Rao, D Ramesh. The Study of Voltage Profile and Power Quality with SVC in Transmission System at Different Loads. *International Journal of Engineering Research and Applications (IJERA).* 2013.
[6] Mark Ndubuka NWOHU. *Voltage Stability Improvement using Static Var Compensator in Power Systems*. Department of Electrical/Computer Engineering, Federal University of Technology, Minna, Niger State, Nigeria. 2009.
[7] Boudjella.Houari, FZ Gherbi, S Hadjeri, F Ghezal. *Modelling and Simulation of Static Var Compensator with Matlab*. Department of Electrical Engineering Djillali Liabes University, Sidi Bel Abbes, Algeria. 2007.
[8] K Venkata Ramana Reddy, M Padma Lalitha, PB Chennaiah. Improvement of Voltage Profile through the Optimal Placement of FACTS Using L-Index Method'. *International Journal of Electrical and Computer Engineering (IJECE)*. 2014; 4(2): 207~211.

[9] MN Dazahra, F Elmariami, A Belfqih, J Boukherouaa. Optimal Location of SVC using Particle Swarm Optimization and Voltage Stability Indexes. *International Journal of Electrical and Computer Engineering (IJECE)*. 2016; 6(6): 2581~2588.
[10] BT Ramakrishna Rao, N Gayatri, P Balaji, K Sindhu. Modeling and Simulation of Static VAR Compensator Controller for Improvement of Voltage Level in Transmission Lines. *International Journal of Electrical and Electronics Research*. 2015.
[11] Yanzhou Sun, Linlin Wei. *Simulation Analysis of Static Var Compensator Based on the Matlab/Simlink*. School of Electrical Engineering & Automation, Henan Polytechnic University, Jiaozuo 454000, China. 2013.
[12] Matthew Simeon, Wara S Tita, Adejumobi A Isaiah, Ajisegiri ESA, Olanipekun A Joseph. *Power System's Voltage Stability Improvement Using Static Var Compensator*. Federal University of Agriculture, Abeokuta. 2014.
[13] Tariq Masood Ch, Abdel-Aty Edris, RK Aggarwal, Suhail A Qureshi, Abdul Jabber Khan, Yacob Y Al-Mulla. *Static Var Compensator (SVC) Modelling and Analysis Techniques by MATLAB.* PSC. 2006. Tehran, Iran. 2013; 1-3.
[14] Nadarajah Mithulananthan. Comparison of PSS, SVC, and STATCOM Controllers for Damping Power System Oscillations. *IEEE Trans. Power System.* 2003; 18: 786-792.