

Literature Review on Improvement of Voltage Stability by using Static Var Compensator

¹Prof.Dhiraj Tikar, ²Prof. Pankaj Ambilduke, ³Prof. Priya Patil

¹Assistant Professor, ²Assistant Professor, ³Assistant Professor

¹Electrical Engineering,

¹sre'S, Shree Ramchandra College Of Engineering, Lonikand, Pune – 412216, India

Abstract— Now a days the power systems under deregulation are challenged to build in new transmission lines for increased power transactions. Reactive power problem can be solved by providing suitable reactive power support at some significant buses. FACTS devices are being growing used to provide not only the reactive power but also to control other aspects of a power system. Voltage instability problems growing day by day because of huge increase demand in power. It is very important to analyze the power system with respect to voltage stability .This paper based on the voltage stability analysis of IEEE 9 BUS systems with SVC.

Index Terms— Voltage Stability; Facts Devices; SVC; IEEE 9 Bus System

I. INTRODUCTION

As the electric power systems have been evolved from last century, different forms of instability have been emerged during different period. Power system stability was first known as an important problem in 1920 which was associated with remote power plants feeding power to load centers over long transmission lines. The stability trouble was caused due to slow exciters and non-continuously acting voltage regulators, which limits the power transfer capability by steady state as well as transient stability limits. It is broadly known that exchanging active and reactive power with a power system can help to improve the power system stability. Modern power system is closely stressed to meet the increasing demand. So the modern power system is facing challenges.

FACTS are innovative devices originating from recent new technologies that are capable of altering voltage, phase angle and impedance at particular points in power systems. Their quick response offers a high potential for power system stability improvement aside from steady-state flow control. Among the FACTS controllers, Static Var Compensator provides fast acting dynamic reactive compensation for voltage support during emergency events which would otherwise depress the voltage for a significant length of time. SVC also damp out power swings and reduces power system losses by optimized reactive power control. Power System Computer Aided Design has been used in this paper to carry out simulations on voltage regulation and load flow capability at the point of connection of SVC to the system. The papers deals through the simulation of SVC on PSCAD and PWS along with the associated details of the circuit design. The static VAR compensator is now grown-up technology that is widely used for transmission applications

II. VOLTAGE STABILITY

Voltage stability is suitable to increasing source of concern in present-day power systems. The problem of unstable voltage is mainly considered as the inability of the network to meet the load demand imposed in terms of inadequate reactive power support or active power transmission capability or both. Voltage stability can be classified as small or large based on the disturbance type in power system. Small voltage stability refers to the capability of the system to control the voltage when tiny perturbations occur, such as changes in the loads. Large voltage stability refers to the ability of the system to control the voltage after being subjected to large disturbances such as load outages, faults, and large-step changes in the loads. System stability can be evaluated by two different methods of analysis: static and dynamic, the details of which are presented in the following subsection.

1. Static analysis

This technique examines the viability of the equilibrium point represented by a specified operating condition of the power system. This technique allows the examination of a wide range of system conditions. The electric utility industry depends on P-V and Q-V curves in order to determine stability at selected buses. The static method is evaluated by means of a variety of techniques such as:

a) Stability study using PV curves

P-V curves are generated by executing a large number of power flows using power flow methods. In this case, a power system is typically modeled with non-linear differential algebraic equations. The P-V curves are the widely-used method of forecasting voltage problem. They are used to determine the loading capability of a power system. The parameter P can also represent the total active power load in an area or the power flow across an interconnection between two areas and the state variable V is the voltage at a certain bus. The power system load is slowly increased and, at each increment, is necessary recomputed power flows until the nose of the PV curve is reached. The P-V curve is obtained by applying an optimal power

flow method. The critical point or nose points in the P-V curve represent the maximum loading of a system. It can be written as P_{max} . The stability margin can be defined by the real power in MW distant from the operating point to the critical point. The inclusion of the Facts device in a power system can increase or decrease the voltage stability margin.

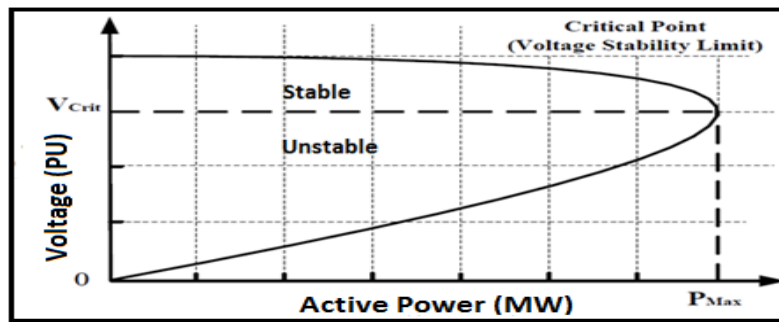


Fig. 1 characteristic of PV curve

b) Q-V sensitivity analysis

In this technique, the network is represented by a power flow equation that can be linearized. The Q-V sensitivity at a bus represents the slope of the Q-V curve (Figure 2) at a given operating point. A positive Q-V sensitivity is indicative of stable operation, and a negative sensitivity is indicative of unstable operation. Fig. 2 shows a characteristic of QV curve

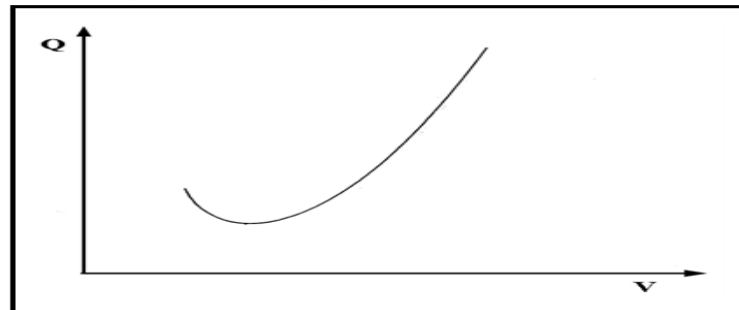


Fig. 2 characteristic of Q-V curve

2. Dynamic Analysis

Dynamic analysis can demonstrate the real behavior of the system such as loads (dynamic and static), DG units, automatic voltage and frequency control equipment, and the protection systems. The overall power system is represented by a putting of first order differential equations, Voltage instability in distribution systems has been understood for decades and was referred to as load instability. For example, an unstable voltage problem in a power system network, which was widespread to a corresponding transmission system, caused a major blackout in the S/SE Brazilian system in 1997. With the growing of economy, load demands in distribution networks increase sharply. Hence, the power system networks are operating closer to the unstable voltage boundaries. The decline of stable voltage margin is one of the most important factors which limit the increase of load served by distribution companies. Therefore, it is essential to consider voltage stability with the integration of FACTS device in power systems. The study considered the unbalance of loads and sources, and was divided into two parts: simulation without SVC FACTS device and then simulation with insertion of SVC FACTS device.

3. Proximity to voltage instability

As mentioned before, the static method can be analyzed by using the relation among the receiving power (P) and the voltage (V) at a certain bus in a system, which is known as a P-V curve characteristics or nose curve characteristics. The P-V curve characteristics are obtained by applying the optimal power flow method. The critical point P_{max} (saddle-node bifurcation point) in the P-V curve represents the maximum loading of a system. The stability margin can be defined by the real power in MW distant from the operating point to the critical point. The inclusion of the SVC device in a power system can increase or decrease the voltage stability margin depending on their loading capability as well as their location. Figure 1 shows a P-V curve of an electrical system. The x-axis represents P in MW, which is the scaling factor of the load demand at a certain operating point. P varies from zero to the maximum loading. However, static analysis method cannot determine the control action and the interaction between the SVC devices in the system. Proximity to the unstable voltage method can be used to determine those issues. The impacts of the SVC device dynamics using small-signal stability analysis have analyzed in this paper. Small-signal stability analysis in power systems is achieved in frequency domain using Eigen value analysis. It is carried out by linearizing the mathematical model of the system and then calculating the values for the Eigen values and Eigen vectors of the linearized model.

As shown in Figure 1 voltage stability is divided into two sections, i.e. large disturbance and small-disturbance. *Large-disturbance voltage stability* consists of maintaining the voltage at different buses of certain acceptable level after the system is subjected to a large. Whereas, *small-disturbance voltage stability* consist of maintaining steady voltages following small perturbations in the system such as load variations. For the entire types of disturbances, the time frame of interest varies

from a few seconds to several minutes. Figure shows that the time frame is separated into short-term and long term voltage stability. *Short-term voltage stability* involves the dynamics components of the system shortly after a disturbance. Short-term instability often arises due to the occurrence of fast acting load components such as induction motor loads, high penetration of distributed generation that is consuming reactive power without voltage control, electronically controlled loads and HVDC converters. Long-term voltage stability is generally studied using static analysis for large-scale power systems under various conditions. Equipment measured for this time scale consists mainly of tap-changing transformers, thermostatically controlled loads and generator current limiters. The main causes of long-term instability include

- Loss of a long-term equilibrium operating point
- Lack of getting a stable post-disturbance equilibrium due to the effect of over excitation limiters
- Tap changers reaching their limits or when operating close to a small-disturbance instability

III. STATIC VAR COMPENSATOR (SVC)

According to the IEEE definition, a Static Var Compensator is a shunt connected static var generator or absorber whose output is adjusted to exchange capacitive or inductive current to maintain or control specific parameters of the electrical power system (typically, the bus voltage). It improves in voltage regulation, reactive power control and improving the transient stability of the system. Static VAR Compensator is a first generation FACTS device that can control voltage at the required bus thereby improving the voltage profile of the system

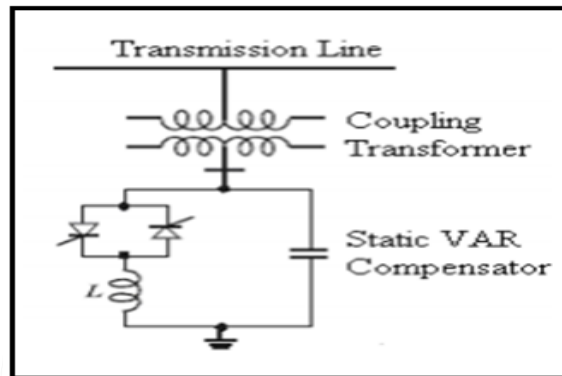


Fig. 3.1 Schematic Diagram of SVC

This SVC consists of a fast thyristor switch controlling a reactor and/or shunt capacitor bank to provide dynamic shunt compensation. It is shunt connected Static Var Generator/Load whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific power system variables.

SVC can be used for

1. Static and Dynamic Voltage Control
2. Oscillation Damping
3. Sub Synchronous Resonance
4. Reactive Power Support
5. To increase power transfer capability

Typically, an Static Var compensator comprises one or more than one banks of fixed or switched shunt capacitors or reactors, of which at least one bank is switched by thyristors. Elements which may be used to make an SVC usually include:

- Thyristor controlled reactor (TCR),
- Thyristor switched capacitor (TSC)
- Harmonic filter(s)
- Mechanically switched capacitors or reactors

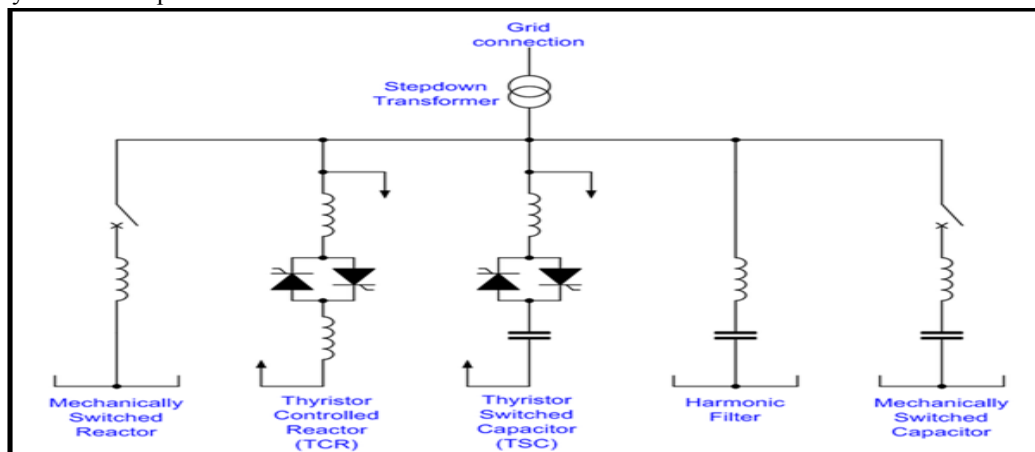


Fig. 3.2 Block Diagram of SVC

IV. SIMULATION OF IEEE 9 BUS SYSTEM

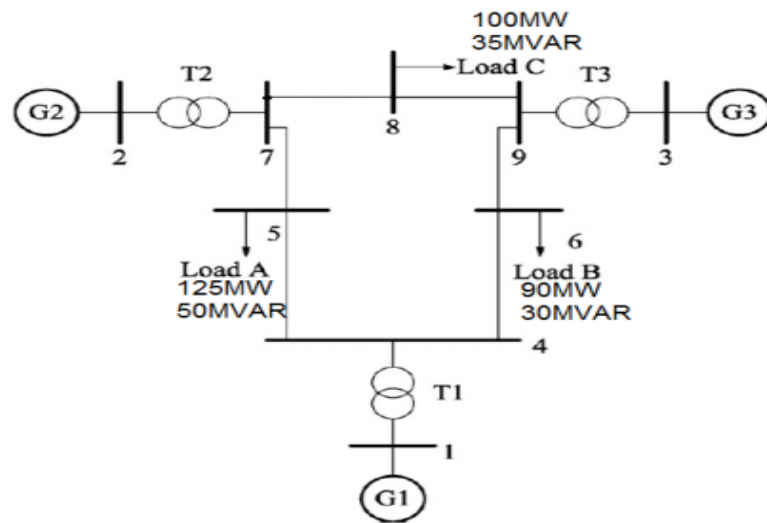


Fig. 4 Single line diagram of IEEE 9 bus system

IEEE 9 bus system consist of 6 transmission line of 1 m length each which are interconnected to buses as shown in Fig. 4. Fundamental system frequency is 60 Hz and base voltage is 230 kV. Three generators of base 77, 163 and 86 MVA are connected to bus 1, bus2 and bus 3 respectively. Whereas, loads are connected at bus no 5, 6 and 8.

V. RESULT AND DISCUSSION

1. Loading Without SVC

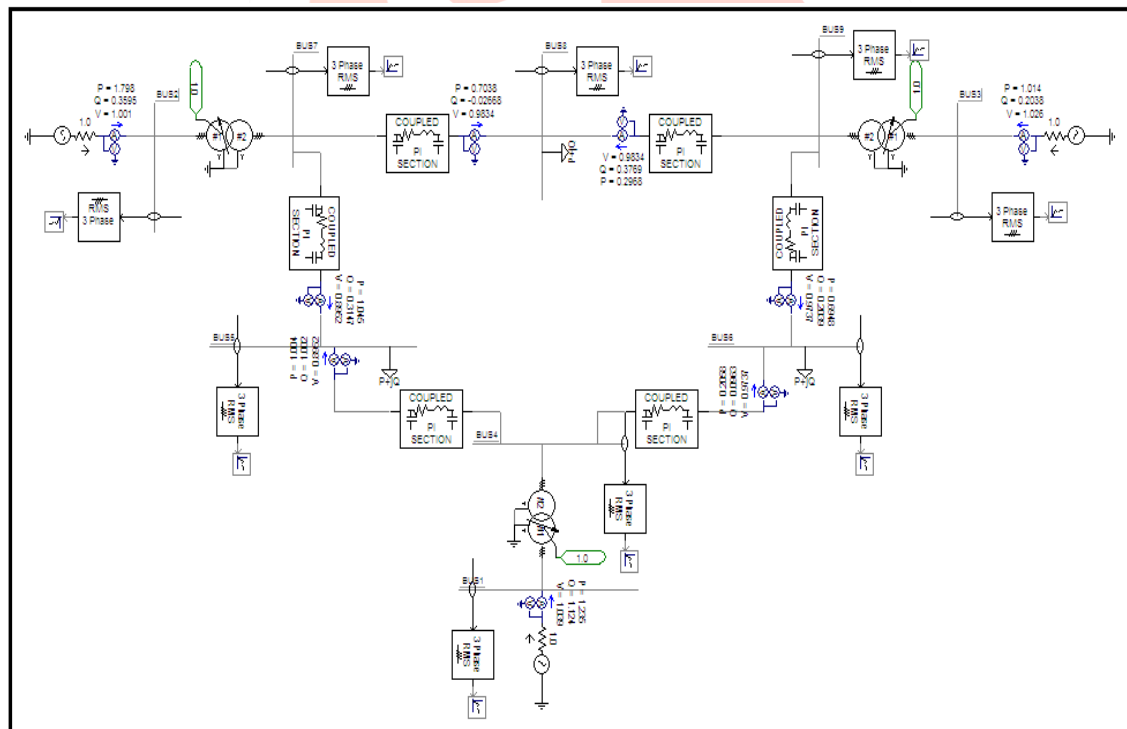


Fig. 5.1 loading condition without SVC in PSCAD

Fig. 5.1 shows simulation of IEEE 9 bus system in PSCAD software during normal and loading condition in which PI section transmission lines of 1 m are used for connecting various buses. Sources are connected to **buses 1, 2 and 3**. **Different** loads are connected to bus No.5, 6 and 8. Three transformers are connected between bus 1 and 4, bus 2 and 7, bus 3 and 9. Multimeters are connected between each line for measuring voltage, current, active and reactive power flowing through the line. Also voltmeters are connected on each bus for measuring Line voltage in pu.

2. Loading with SVC

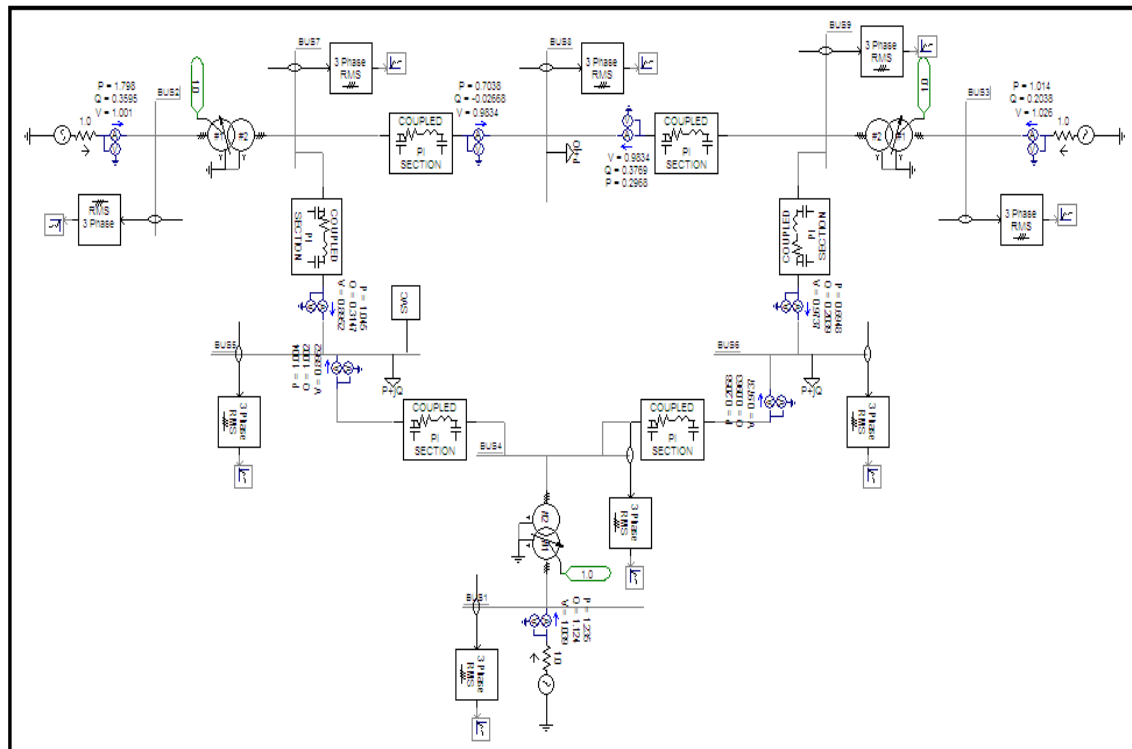


Fig. 5.2 loading condition with SVC in PSCAD.

Fig 5.2 shows simulation of IEEE 9 bus Test system in PSCAD Software for different loading condition with connecting SVC at bus no 5.

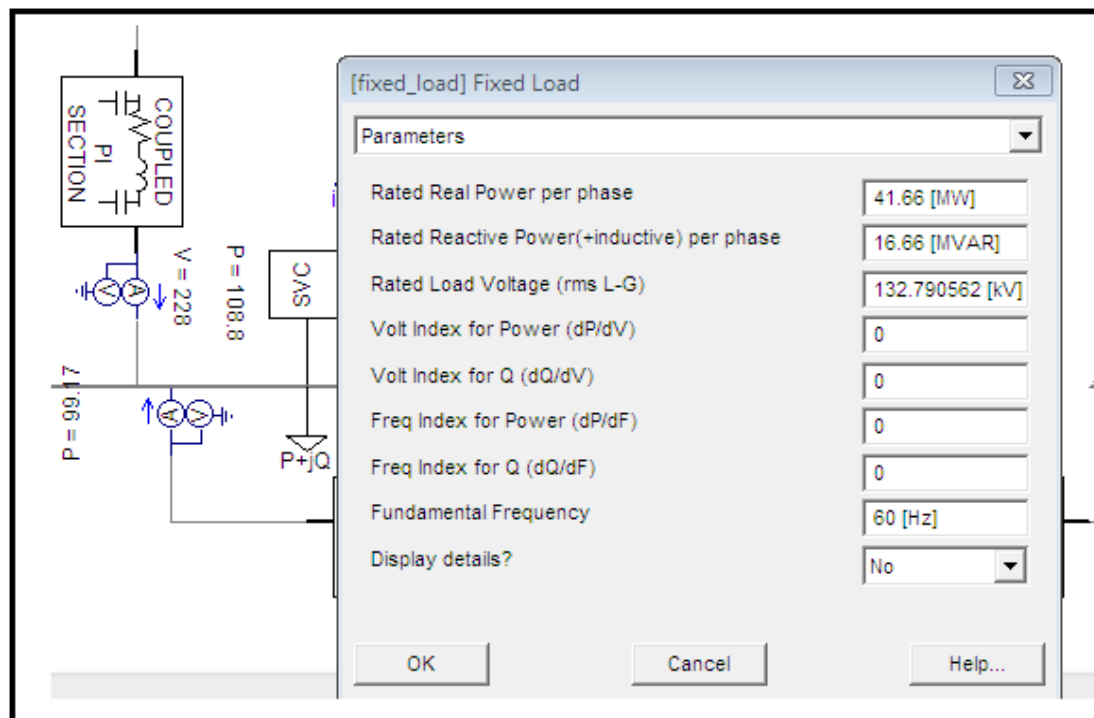


Fig. 5.3 loading condition changed using fixed load parameter

Fig. 7 shows the loading part of 9 bus system in PSCAD software. So from this parameter we changed the load according to our convenient need.

VI. CONCLUSION

In this dissertation, the basic structure of an SVC operating under typical bus voltage control and its model are described. This shows, the effectiveness of shunt FACTS devices such as SVC has been studied in improving the system stability of an IEEE 9 bus system. The simulation results shown here the effective working of SVC for improving the voltage stability of system.

REFERENCES

- [1] IEEE Special Stability Controls Working Group "Static Var Compensator Models for Power Flow and Dynamic Performance Simulation" IEEE Transactions on Power Systems, Vol. 9, No. 1, February 1994
- [2] Olimpo Anaya-Lara and E. Acha "Modeling and Analysis of Custom Power Systems by PSCAD/EMTDC IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 17, NO. 1, JANUARY 2002
- [3] Gagari Deb, KabirChakraborti and Sumita Deb "Voltage Stability Analysis using Reactive Power Loading as indicator and Its Improvement by FACTS Device" 1st IEEE International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES-2016)
- [4] RenukaKamdar, Manoj Kumar, Ganga Agnihotri "Transient Stability Analysis And Enhancement of IEEE-9 Bus System"Electrical & Computer Engineering: An International Journal (ECIJ) Volume 3, Number 2, June 2014
- [5] 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 Leonardo Journal of Sciences ISSN 1583-0233 Issue 14, January-June 2009 p. 167-172
- [6] B. T. Ramakrishna Rao, N. Gaytri, P. Balaji, K. Sindhu "Modeling and Simulation of Static Var Compensator controller for improvement of voltage level in transmission line".

